DEPARTMENT OF THE NAVY
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5090
Ser 06CM.JV\0250
March 1, 2004

Mr. James Ponton
California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, #1400
Oakland, CA 94612

Dear Mr. Ponton:

Subj: ANNUAL SITE STATUS REPORT (FOR THE YEAR 2003) FOR FORMER UST SITE 957/970 AT DEPARTMENT OF DEFENSE HOUSING FACILITY, NOVATO, CALIFORNIA

I have enclosed for your review the **Annual Site Status Report (for the Year 2003) for Former UST Site 957/970 at Department of Defense Housing Facility, Novato, California**. This document was prepared in accordance with Task 9 of Order No. 00-064 for Department of Defense Housing Facility, Novato. Please note that the annual recommendations for modification of the monitoring program are summarized in Section 6.1 and Table 15.

We would appreciate your written concurrence or comments (if necessary) by March 31, 2004. Please feel free to contact me at (619) 532-0919 should you have questions regarding this submittal.

Sincerely,

JENNIFER R. VALENZIA
BRAC Environmental Coordinator
By direction of the Commander

Encl: (1) Annual Site Status Report (for the Year 2003) for Former UST Site 957/970 at Department of Defense Housing Facility, Novato, California

5090
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Annual Site Status Report (For the Year 2003) For Former UST Site 957/970 at Department of Defense Housing Facility Novato, California

Prepared for

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CONTRACT NUMBER: N47408-01-D-8207
DELIVERY ORDER: 0026

by

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February 2004

ANNUAL SITE STATUS REPORT
(for the Year 2003)

FOR FORMER UST SITE 957/970
AT DEPARTMENT OF DEFENSE HOUSING FACILITY
NOVATO, CALIFORNIA

Contract No. N47408-01-D-8207
Task Order No. 0026

Prepared for:

Naval Facilities Engineering Command
Southwest Division
1220 Pacific Highway
San Diego, California 92132-5190

and

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February 27, 2004

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ACRONYMS AND ABBREVIATIONS

BTEX	benzene, toluene, ethylbenzene, and xylenes
btoc	below top of casing
cfm	cubic feet per minute
CSWRCB	California State Water Resources Control Board
DIPE	diisopropyl ether
DO	dissolved oxygen
DoDHF	Department of Defense Housing Facility
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ETBE	ethyl tertiary butyl ether
FOST	finding of suitability to transfer
GC/MS	gas chromatography/mass spectrometry
HAAF	Hamilton Army Airfield
HCl	hydrochloric acid
ID	identification
LUFT	Leaking Underground Fuel Tank
LUC	land use covenant
MNA	monitored natural attenuation
MTBE	methyl-*tert*-butyl ether
NA	not analyzed
N/A	not applicable
NEX	Naval Exchange
NFESC	Naval Facilities Engineering Service Center
NS	not sampled
PQL	practical quantitation limit
PWC	Public Works Center
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
RBCA	Risk Based Corrective Action
RWQCB	Regional Water Quality Control Board, San Francisco Bay Area
SVE	soil vapor extraction

TAME	tertiary amyl methyl ether
TBA	tert butyl alcohol
TBF	tert butyl formate
TMB	trimethylbenzene
TPH	total petroleum hydrocarbons
TPH-G	total petroleum hydrocarbons quantified as gasoline
UST	underground storage tank
VOA	volatile organic analysis
VOC	volatile organic compound

Section 1.0: INTRODUCTION

This site status report describes activities performed under Task Order No. 0026 of the U.S. Naval Facilities Engineering Service Center (NFESC) Contract No. N47408-01-D-8207 and was prepared in compliance with Regional Water Quality Control Board, San Francisco Bay Area (RWQCB) Order No. 00-064, Task 9. In accordance with the Order, this report presents the results of quarterly groundwater and surface water monitoring conducted in August and November 2003. It also contains the results of the biosparging and performance well monitoring activities that were conducted through December 2003, and summaries the bedrock well installation activities which occurred in November 2003. An annual evaluation of the groundwater and surface water monitoring program is included to ensure that monitoring objectives have been met in an efficient manner. Based on the evaluation of the monitoring program, recommendations to modify the sampling frequency and sampling network without compromising the objectives of the program have been provided.

The subject of this report is former Underground Storage Tank (UST) Site 957/970 at Department of Defense Housing Facility (DoDHF) Novato, which is located approximately 20 miles north of San Francisco in Marin County, CA. The Site comprises an area of approximately 13 acres of land (an approximate rectangle with dimensions approximately 1,100 ft by 500 ft) bounded on the south by Main Entrance Road, and on the north by a set of railroad tracks operated by the Golden Gate Bridge, Highway, and Transportation District. The eastern border of the Site runs north-south from the intersection of Main Entrance Road and C Street, and the western border of the Site runs north-south approximately 500 ft west of the intersection of Main Entrance Road and C Street (see Figure 1). The Site is the location of a former Naval Exchange (NEX) gas station and a former Public Works Center (PWC) gas station. The NEX gas station was located at the northwest corner of Main Entrance Road and C Street, where Building 970 and associated pump islands were in use from the mid-1970s through the early 1990s. The NEX gas station was closed in the early 1990s, and subsequently the three (3) USTs that had supported the station (UST 970-1, UST 970-2, and UST 970-3, collectively referred to as UST 970) were removed. The PWC gas station was the location of UST 957; this UST and associated underground piping were removed in 1992.

Water and soil samples were collected from excavations during tank removal activities in the areas of former USTs 957 and 970. Analytical results from these samples indicated that gasoline was released to the environment from the USTs. Because the groundwater plumes underlying these areas have merged and are no longer distinguishable, the individual Site designations have been combined and the label “Former UST Site 957/970” has been adopted.

Starting June 1998, an interim remedial action consisting of air sparging and soil vapor extraction (SVE) was implemented to reduce hydrocarbon mass in areas in which the highest hydrocarbon concentrations were observed in groundwater. Significant mass removal was achieved, and the air sparging and SVE systems were shut down in early October 1999 because of greatly diminished mass removal rates. In September 2002, a biosparging system was initiated at the site to mitigate elevated MTBE concentrations on Navy-owned property. This remediation system will be operated until the objectives defined in the *Final Remedial Design and Work Plan* (Battelle, 2002a) have been achieved or the system no longer cost-effectively removes MTBE. Groundwater monitoring to track the behavior of dissolved gasoline constituents continues to be conducted on a quarterly, semiannual, or annual basis as described in Section 5.1 of the *Annual Site Status Report (for the Year 2002)* (Battelle, 2003a).

Section 2.0: SUMMARY OF SITE ACTIVITIES

This section includes a summary of Site activities performed from June 2003 through December 2003. Previous project and Site activities have been reported in Semiannual Site Status Reports and monthly reports.

2.1 Board Order Deliverable Items

In various correspondence from the RWQCB to the Navy (letters from Mr. James Ponton to Mr. Thomas Macchiarella dated December 18, 2001, March 20, 2002, and April 16, 2003), it is documented that the Navy has met the requirements of Cleanup and Abatement Order 00-064. Some of the tasks included in the Order require that the Navy continue performing some activities at the Site. The Navy will fulfill the continuing obligations that are included in the Order and that are summarized below:

- **Task 6:** Implement the RWQCB-approved remedial approach (biosparging with a SVE contingency, monitored natural attenuation, and institutional controls) recommended in the *Final Corrective Action Plan for Groundwater* (Battelle, 2002b).
- **Task 8:** Update the *Groundwater Monitoring Plan* (Battelle, 2000a) for the Site by presenting recommendations in the regular site status reports that will allow all data objectives to continue to be met in a cost-effective manner.
- **Task 9:** Monitor groundwater and surface water and report the results collected during those monitoring activities in semiannual site status reports.

The main project documentation prepared by the Navy are the semiannual site status reports, which are included under Task 9. In August 2003 the Navy submitted the *Semiannual Site Status Report (for the Months February and May 2003) for Former UST Site 957/970 at Department of Defense Housing Facility Novato, California* (Battelle, 2003b) in August 2003, in compliance with Task 9 of Order No. 00-064. The report presented interpretations of data that were generated by the quarterly groundwater and surface water sampling events conducted in February and May 2003, as well as the results of biosparging and performance well monitoring activities that occurred from December 2002 through May 2003.

2.2 Field Activities

Field activities that were conducted at the Site between June and December 2003 included quarterly groundwater and surface water sampling, regular biosparging system operation and monitoring, and bedrock well installation activities. Details regarding each of these field events are as follows:

- Performed quarterly groundwater and surface water sampling at the Site from August 6, through August 15 and from November 5 through November 15, in accordance with the *Groundwater Monitoring Plan* (Battelle, 2000a). Groundwater sampling was conducted according to the protocol presented in Table 5 and Table 12 of the *Annual Site Status Report (for the Year 2002)* (Battelle, 2003a). Results from groundwater and surface water sampling are described in further detail in Sections 3.0 and 4.0, respectively, and in appendices of this report.
- Biosparging activities such as system operation and performance monitoring were performed from June 2003 through December 2003. Biosparging activities are summarized in Section 5.0 of this report. Regular monitoring of subsurface conditions

during biosparging was continued as outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a). Weekly visits were made to the site by the subcontractor (ERRG) to confirm that the system continued to operate properly and that safe conditions were being maintained.

- Three additional bedrock wells were installed from November 17 through November 22, 2003, in accordance with *Final Work Plan Describing Proposed Bedrock Well Installation Activities* (Battelle, 2003c). The additional bedrock wells were installed near preexisting monitoring wells that are screened in the shallow alluvium (MW-M2, MW-M8, and MW-2E). A summary of the drilling activities is provided in Appendix E and the analytical data from the new bedrock wells is provided in Section 3.6.2.

2.3 Other Activities

On October 6, 2003 the Navy issued the *Final Work Plan Describing Proposed Bedrock Well Installation Activities* (Battelle, 2003c). This document incorporated responses to all regulatory comments and describes the installation procedures for the bedrock wells.

Section 3.0: GROUNDWATER MONITORING

The final two quarterly groundwater-monitoring events for the year 2003 are summarized in this section. Groundwater monitoring for the third quarter was conducted from August 6 through August 15 and for the fourth quarter from November 5 through November 15, in accordance with the *Groundwater Monitoring Plan* (Battelle, 2000a), the *Draft Health and Safety Plan* (Battelle, 1998), and the RWQCB letter of March 13, 2003. Fifty-three groundwater samples (excluding duplicates and quality control samples) were collected during the August 2003 quarterly monitoring event, and 78 groundwater samples (excluding duplicates and quality control samples) were collected during the November 2003 quarterly monitoring event. This section presents the results from both of these sampling events.

Well inspections were performed during groundwater monitoring activities in accordance with the *Monitoring Well Protection Plan* (Battelle, 2000b). Significant damage or deterioration that could impact well function or protection was not observed. Corrective actions taken in the August and November 2003 sampling events were limited to general maintenance of wells (i.e., cleaning seals and identification [ID] tags, etc.). Observations are included on the well purge and maintenance log sheets provided in Appendix A.

3.1 Analytical Program

Sampling objectives for monitoring wells included in the monitoring well network are provided in Table 1 of this document. Sampling and analytical methods are summarized in Table 2 and laboratory practical quantitation limits (PQLs) for analytes based on clean matrices are listed in Table 3. Table 4 provides the number of quality control (QC) samples and Table 5 provides a summary of the monitoring analytical program for all of the wells. Table 5 contains the modifications that have been made to the sampling protocol since they were originally presented in Tables 2 and 4 of the *Groundwater Monitoring Plan* (Battelle, 2000a). Samples collected during the August and November 2003 quarterly monitoring events were analyzed for total petroleum hydrocarbons (TPH) quantified as gasoline (G) using U.S. Environmental Protection Agency (EPA) Method 8015B; and for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and methyl-*tert*-butyl ether (MTBE) by EPA Method 8260B in accordance with the sampling protocol summarized in Table 5. In addition, the fuel oxygenates, ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), and diisopropyl ether (DIPE), and degradation products tert butyl alcohol (TBA) and tert butyl formate (TBF) were also analyzed for in some wells, which is indicated in Table 5.

Reporting limits for benzene of 0.5 μg/L were achieved in all samples determined to be nondetect in the August 2003 and November 2003 sampling events.

3.2 Water-Level Measurements

Prior to sampling, a water-level measurement was taken from each monitoring well and recorded in the purge logs in accordance with the *Groundwater Monitoring Plan* (Battelle, 2000a). Groundwater was measured as depth below top of casing (btoc). Groundwater-level elevation was determined by subtracting the depth of groundwater btoc from the surveyed elevation of a reference point marked at the top of casing. In the nested well pairs (with the exception of nested well pair MW-M20), depths to groundwater used for the potentiometric map were measured from the upper nested well of each pair. Cumulative water-level measurements are tabulated and included as Appendix B, and potentiometric maps for the August and November 2003 sampling events are presented on Figure 2 along with the potentiometric maps for the first two quarters in 2003. Groundwater flow in August and November is similar to that reported for previous quarters. In fact, groundwater flow was fairly consistent among all the quarters. No discernable changes in groundwater flow direction are evident in the biosparging treatment area since the system was started in September 2002. Because of the spatial placement of wells, the potentiometric maps should be used to make general observations about groundwater flow and not to determine localized flow patterns.

3.3 Purging and Sampling

Prior to sampling, wells were purged to remove stagnant water in accordance with procedures outlined in the *Groundwater Monitoring Plan* (Battelle, 2000a). Purging was considered adequate when the required volume of water was removed and field parameter readings had stabilized, or when the well was determined to be a slow recharging well (the well had purged dry). Samples were collected immediately from wells in which the required volume was purged and field parameters had stabilized. After purging to dryness, slow recharging wells were sampled when a sufficient volume of groundwater was present in the well to meet sample volume requirements. The criteria used to stop purging each well were recorded on the purge log sheets provided in Appendix A.

Upon completion of purging, samples were collected and acidified with hydrochloric acid (HCl) for preservation in accordance with the *Groundwater Monitoring Plan* (Battelle, 2000a). Following collection, all samples were labeled and stored at approximately 4°C until they were shipped and received by a State of California-certified laboratory. Each well was secured upon completion of sampling according to the protective measures described in the *Monitoring Well Protection Plan* (Battelle, 2000b). All purge water and water used to decontaminate the equipment was contained in drums or polyethylene tanks prior to disposal.

3.4 Quality Assurance/Quality Control Summary

All groundwater samples were collected and preserved in accordance with the methods stated in the *Groundwater Monitoring Plan* (Battelle, 2000a) and analyzed within the prescribed analytical holding times. Laboratory QC summary reports are provided in Appendix C. The laboratory's quality assurance (QA) oversight involved the performance of a first-level screening of the data and an indication of any deviations from their precision, accuracy, reporting limit, or laboratory QC criteria. A representative from the laboratory signed the data sheets, ensuring that the screening described above had been completed. Subsequently, Battelle completed data validation as described in the *Groundwater Monitoring Plan* (Battelle, 2000a).

Quality assurance/quality control (QA/QC) samples were collected in the field to ensure that meaningful and representative data sets were generated. Table 4 summarizes the frequency of QC sample collection. During the August 2003 and November 2003 quarterly monitoring event, six and eight field duplicate samples, respectively, were collected to ensure the consistency and integrity of sample collection methods. All duplicate samples showed consistency in results. Summary tables of all the analytical results are included in Appendix D.

Dedicated sample tubing is used for each well rather. Equipment rinsate samples were collected to ensure that sampling devices did not contribute to analyte concentrations in the samples. Five rinsate samples were collected during the August 2003 quarterly monitoring event. Analytical results for two of the five rinsate samples (957-MW4-ER and IT-PZ-7-ER) indicated the presence of one or more of the following analytes: MTBE in 957-MW4-ER, and benzene, xylenes, and toluene in IT-PZ7-ER. MTBE and toluene were the only compounds detected at concentrations greater than their PQL of 0.5 µg/L, which is the lowest level at which the compound can be accurately quantified. All other compounds were detected at levels less than their respective PQLs. The associated sample collected from

957-MW4 had a MTBE concentration of 12,000 μg/L. The associated sample from IT-PZ-7 reported concentrations of toluene below the PQL of 0.5 μg/L.

Six rinsate samples were collected during the November 2003 quarterly monitoring event. Analytical results for three of the six rinsate samples (NA-4-ER, MW-6A-ER, and MW-M27S-ER) indicated the presence of MTBE or toluene at estimated concentrations less than their PQL of 0.5 μg/L. The associated samples collected from MW-9A and MW-8A reported a toluene concentration less than the PQL level of 0.5 μg/L. The associated sample collected from NA-4 reported a MTBE concentration of 2,600 μg/L. The associated samples collected from MW-6A and MW-M27S reported toluene concentrations of 5.6 μg/L and less than 0.5 μg/L, respectively. Because dedicated tubing is used at these wells, the presence of these compounds is most likely associated with groundwater from these wells.

3.5 Deviations from the Groundwater Monitoring Plan

Deviations from the sampling protocol outlined in the *Groundwater Monitoring Plan* (Battelle, 2000a) included the following:

August Monitoring Event

- Certain wells were not sampled during the August sampling event due to changes in the monitoring program (see Table 5). These wells are: MW-1A, MW-4A, MW-10A, MW-1B, 970-MW1, 970-MW2, 970-MW4, 970-MW5, NA-0, PZ-4, MW-M11, MW-M12, MW4B, MW-5A, MW-6B, MW-M24, IT-MW-81S, MW-M14S, MW-M20S, MW-M25S, MW-M25D, MW-M26S, MW-M27S, MW-M27D, IT-EW-91-1, and IT-2MW-2.
- The following wells purged dry before three well volumes were recovered; however, samples were collected from these wells and submitted for analyses: 970-MW3, MW-M8, 957-MW4, MW-3D, MW-6A, MW-8A, NA-4, NA-7, MW-2D, MW-9A, IT-GMP-18, MW-M15, MW-M20D, MW-M21, MW-M22, MW-M23, MW-M19, MW-1E, MW-M14S.
- Samples were not collected from PZ-11 because this well was dry.
- Well PZ-1 was not purged, just sampled due to slow recharge/low well volume.

November Monitoring Event

- Groundwater samples from wells in Area A (970-MW1, MW-5A, MW-6A, MW-1A, and MW-7A), Area D (MW-1D, MP-1D, 957-MW4, and 957-MW3), the benzene plume perimeter wells (NA-0, 970-MW1, 970-MW2, 957-MW1, 957-MW3, 970-MW3, MW-3B, and MW-10A), and the bedrock wells (MW-9A and MW-3D) were analyzed for the fuel oxygenates ETBE, TAME, and DIPE, and MTBE degradation products TBF and TBA (Table 5). Results are summarized in Appendix D.
- The following wells purged dry before three well volumes were recovered; however, samples were collected from these wells and submitted for analyses: 957-MW4, MW-M12, MW-M22, MW-M23, NA-0, MW-9A, MW-6A, MW-4A, MW-3B, MW-1E, IT-MW-81S, IT-GMP-18, MW-3D, NA-7, MW-M10, MW-2D, MW-6B, 970-MW5, MW-M20S, MW-M26S, MW-M15, MW-M14S, MW-M20D, MW-M19, MW-M8, MW-M21, MW-M25S, MW-M14D, 970-MW3, NA-4, PG-MW5.
- Samples were not collected from PZ-11 because this well was dry.

- Wells PZ-1 and PZ-10 were not purged, just sampled due to slow recharge/low well volume.

3.6 Summary of Findings

This section provides a summary of findings for the August and November 2003 groundwater-sampling events. Copies of original laboratory data sheets are provided in Appendix C. Tabulated results of the cumulative groundwater analytical data are provided as Appendix D.

3.6.1 Maximum and Average Concentrations. Maximum concentrations of benzene and MTBE in groundwater were 110 µg/L and 20,000 µg/L, respectively, for the August 2003 quarterly monitoring event and 230 µg/L and 23,000 µg/L, respectively, for the November 2003 monitoring event (Table 6). Average concentrations of benzene and MTBE in groundwater were 5 µg/L and 1,964 µg/L, respectively, for August 2003 and 7.3 µg/L and 1,776 µg/L, respectively, for November 2003. The historical maximum and average concentrations of gasoline constituents of concern for each historical monitoring event also are presented in Table 6. These concentrations are in line with the generally decreasing trends that have been observed over time during previous sampling.

The maximum concentrations of benzene in August 2003 and November 2003 (110 µg/L and 230 µg/L, respectively) are less than those observed last year in August 2002 and November 2002 (130 µg/L and 240 µg/L, respectively). The maximum MTBE concentration for the August 2003 sampling event is the same as the concentration detected in the August 2002 sampling event (20,000 µg/L). A comparison of the maximum MTBE concentration with previous sampling data from the fourth quarter indicates that the November 2003 quarterly monitoring event (23,000 µg/L) is greater than the November 2002 sampling event (20,000 µg/L), but less than the November 2001 sampling event (32,000 µg/L), and the November 2000 sampling event (35,000 µg/L).

The average concentrations of benzene during the August 2003 and November 2003 sampling events (5 µg/L and 7 µg/L, respectively) are less than those observed during August 2002 and November 2003 (8 µg/L and 9 µg/L, respectively) and all other preceding August and November sampling events (Table 6). Similarly, the average concentrations of MTBE during the August and November 2003 sampling events are less than the average concentrations observed during the August and November 2002 monitoring events, and less than previous August and November monitoring events. Average concentrations reported in Table 6 were calculated using one-half of the detection limit for nondetect results during each quarterly monitoring event. The comprehensive benzene and MTBE data indicates that maximum and average concentrations are decreasing. These decreasing maximum and average concentrations indicate a long-term decreasing concentration trend.

3.6.2 Bedrock Wells. Three additional bedrock wells were installed during the fourth quarter in 2003 (MW-2E-BR, MW-M2-BR, and MW-M8-BR). Well installation activities, including a description of the field work, location map, construction diagrams, and well logs for the new bedrock wells have been provided as Appendix E. A summary of the analytical data for all the bedrock wells is presented in this section and provided in Appendix D along with the other groundwater and surface water tabulated data.

Results of laboratory analyses performed on the groundwater samples collected from the bedrock wells (MW-9A, MW-3D, MW-2E-BR, MW-M2-BR, and MW-M8-BR) during the August and November 2003 quarterly monitoring events are presented in Table 7. Note that groundwater samples were collected from the new bedrock wells on December 9, 2003 and not during the quarterly monitoring event because the wells had not been installed yet. Each of the bedrock wells listed in Table 7 is grouped with another monitoring well that is screened nearby, in the shallow alluvium. One of the main objectives of the chemical analyses conducted on groundwater samples collected from the bedrock wells and nearby alluvial wells is to determine if there is a continuous aquifer at the Site rather than an alluvial aquifer and separate bedrock aquifer. Based on the data provided in Table 7, it is evident that the majority of chemical concentrations detected in the bedrock wells are of the same order of magnitude as the concentrations detected in the nearby alluvial wells. For example, the MTBE concentrations in bedrock well MW-9A and alluvial well MW-5A were reported at 150 μg/L and 110 μg/L, respectively, for November 2003. This consistency in results indicates that groundwater sampled from this bedrock well is likely from the same groundwater unit contained in the alluvial aquifer.

Two inconsistencies that might be a result of well installation activities were observed at the new bedrock wells MW-M2-BR and MW-M8-BR. The MTBE concentrations detected in bedrock well MW-M2-BR and alluvial well MW-M2 were reported at 140 μg/L and 0.4J μg/L respectively. The MTBE concentrations detected in bedrock well MW-M8-BR and alluvial well MW-M8 were reported at 19 μg/L and 4,700 μg/L, respectively. The groundwater samples from the new bedrock wells might differ from those collected from the alluvial wells because samples could not be collected at the same time since the bedrock wells were not yet installed. In addition, it is plausible that the bedrock well installation activities may have affected the analytical results of the groundwater samples. Future monitoring at the additional bedrock well locations will be conducted on a quarterly basis to provide a more representative comparison of groundwater in the bedrock and shallow alluvium.

Geochemical parameters including calcium, magnesium, sodium, potassium, alkalinity (including carbonate and bicarbonate), sulfate, and chloride were analyzed for in groundwater samples collected from all the bedrock wells (except MW-9A) and nearby alluvial wells. The results from these analyses were compared graphically by plotting the results on a Piper diagram (also referred to as a trilinear diagram) and by comparing the Stiff patterns. Both of these graphical analyses are commonly used to compare the geochemical character of groundwater collected from different sources. Figure 3 through Figure 6 presents the results of samples collected from August 2003 through December 2003. Using the Piper diagram, the percentage composition of anions, cations, and total ions can be displayed on a graph. The major cations are plotted on one diagram while the major anions are plotted on another diagram. A third, diamond-shaped field located between the two trilinear diagrams represents the composition of water with respect to both cations and anions (Fetter, 1988). Groundwater of similar compositions will plot in the same general area of the graph as shown on Figures 3 through 6. Again, note that some of the analytical results of groundwater samples collected from the new bedrock wells could be affected by well installation activities.

A second graphical means of comparing groundwater geochemistry is the Stiff pattern. Using the Stiff pattern, the cations and anions are plotted on opposite sides of a vertical line and when data points are connected they form a polygonal shape. These shapes, generated for each groundwater sample, are then compared to the shapes from other samples. This comparison can be made on Figure 3 through Figure 6. These patterns provide a means by which the chemistry of different water samples can be easily compared (Fetter, 1988). While the bedrock well pattern does not exactly match the pattern generated for the alluvial well, the similarity between them provides good evidence that these waters are likely from the same source but different hydrochemical facies. In general, the results of these evaluations indicate that the water in both the bedrock and alluvium are of similar composition. These data, combined with the similar MTBE concentrations in alluvial and bedrock wells, indicate that it is very likely that groundwater beneath the site exists as one hydrologic unit rather than an alluvial aquifer and a separate bedrock aquifer. Quarterly monitoring will continue at the bedrock well and alluvial well locations so comparisons can be made of the analytical results from groundwater samples.

3.6.3 Nested Well Pairs. Five nested well pairs were installed within the alluvial aquifer on former Hamilton Army Airfield (HAAF) property to determine if a variation of MTBE concentrations exists between the upper and lower levels of the aquifer. Historical analytical results from the well pairs do not provide evidence of MTBE stratification (see Table 8). For the August 2003 sampling event, the deep wells, MW-M14D, MW-M20D, and MW-M26D, plus the shallow well, MW-M14S, were sampled due to changes in monitoring requirements (Table 5). Concentrations observed in these wells in August 2003 were less than those reported for May 2003, and generally less than those reported in August 2002 Table 8). For the November 2003 sampling event, all shallow and deep wells were sampled. MTBE concentrations of less than detection (<0.5 μg/L) were observed both in MW-25S and MW-M25D. MTBE concentrations of 210 and 400 μg/L were observed in MW-M14S and MW-M14D, respectively. The concentration of MTBE was reported at 380 and 290 μg/L in nested well pair MW-M26S and MW-M26D, respectively, and was reported at 2.8 and 2.8 μg/L for shallow and deep intervals, respectively, of nested well MW-M27. These data along with the previous quarters of analytical data collected from the nested well pairs indicate that similar MTBE concentrations exist at varying aquifer depths, even during different seasons of the year.

3.6.4 Water-Level Measurements Over Time. The groundwater-level measurements collected during the August and November 2003 sampling event indicated that the groundwater elevation was generally consistent with historical observations. Appendix B contains the cumulative water level measurements for all Site wells. Figure 7 shows water levels over time at selected wells along the centerline of the Site, covering the length of the MTBE plume. Seasonal fluctuations in groundwater elevations are evident over time (Figure 7), with water levels highest in February and much lower in August and November. The general groundwater flow direction to the north has been relatively constant over the last four quarterly monitoring events (Figure 2).

3.6.5 Concentration Versus Time Trends. Graphical representations of selected data inputs for decision criteria (as defined in Table 3 of the *Groundwater Monitoring Plan* [Battelle, 2000a] and revised in Table 1 of the *Annual Site Status Report (for the Year 2002)* (Battelle, 2003a) are presented in Figures 9 through 20 for both the August and November 2003 monitoring events.

Concentration versus time graphs are provided for transect wells located in Area A (Figures 8 and 9), Area B (Figures 10 and 11), and Area D (Figures 12 and 13). Figures 8 and 9 show benzene and MTBE concentrations, respectively, for transect wells located in Area A (near former UST 970). The figures illustrate general decreasing concentrations of both benzene and MTBE over time. Seasonal fluctuations are evident throughout the 2001, 2002, and 2003 sampling events in MW-6A for benzene where concentrations start increasing in August, peaking in November, then decreasing in February and May (Figure 8). Benzene concentrations in wells MW-7A, MW-5A, 970-MW1, and MW-1A continued to decrease or remain consistent throughout 2003. For MTBE (Figure 9), concentrations in MW-7A continue to show cyclic increasing concentrations in February, as it has since 2001, whereas concentrations of MTBE in the other transect wells have remained consistent over the 2003 sampling events as well as consistent with the 2002 sampling events.

Generally, decreasing benzene and MTBE concentrations continue to be observed in Area B transect wells (Figures 10 and 11). Area D (near former UST 957) transect wells, as shown in Figures 12 and 13, continue to show fluctuating benzene and MTBE concentrations, but an overall decreasing trend is evident for both benzene and MTBE. Area D benzene concentrations (Figure 12) have remained relatively constant in wells 957-MW3 and 957-MW4. The benzene concentrations in MP-1D have exhibited decreasing concentrations throughout 2003. However, the benzene concentrations in MW-1D continue to fluctuate in the first quarter sampling events as shown for 2001, 2002, and 2003. MTBE concentrations in Area D (Figure 13) continue to fluctuate among sampling events; however, MTBE concentrations have generally decreased since November 1999. The overall decreasing trend in Area A and the lack of a consistently increasing trend in Area D indicate that a continual source to groundwater does not exist based on the decision criteria established in Table 3 of the *Groundwater Monitoring Plan* (Battelle, 2000a).

Figures 14 and 15 plot benzene and MTBE concentrations, respectively, in plume perimeter wells over time. Figure 14 illustrates that benzene has not been detected above the reporting limit in any perimeter wells, indicating that a stable benzene plume exists. The MTBE plume perimeter wells included in Figure 15 show relatively stable MTBE concentrations with the exception of IT-GMP-17, IT-PZ-5, and MW-M13. The MTBE concentrations in IT-GMP-17 continue to exhibit an increasing trend. Because MTBE has been detected at IT-GMP-17, monitoring well IT-GMP-18 serves as the plume perimeter monitoring well in the northeast portion of the plume. Concentrations of MTBE continue to remain below detection limits in IT-GMP-18. MTBE concentrations in IT-PZ-5 dropped to below detection limits in February 2003, May 2003, August 2003, but increased to 3.7 μg/L in November 2003. MTBE concentrations at MW-M13 have been increasing since November 2001. Stable MTBE concentrations in other wells included on Figure 15 indicate that little to no plume migration is occurring in areas other than IT-GMP-17 and MW-M13. The MTBE concentration in MW-M2 exhibited a noticeable decrease in February 2003 from the November 2002 sampling event and stayed below detection limits throughout 2003. The November seasonal spikes of MTBE in MW-M2 that began in 1999 did not occur in the November 2003 sampling event.

Figures 16 through 19 show benzene and MTBE concentrations along their respective plume center during August and November for the 1999 through 2003 monitoring events. The benzene concentrations in August 2003 and November 2003 (Figures 16 and 17, respectively) are generally lower than those reported in August and November 2002, which are also lower than those reported in August and November 2001, 2000, and 1999. These results indicate that no significant rebound of benzene concentrations has occurred since interim remedial action (in situ air sparging/SVE) activities were concluded in October 1999. Figures 18A and 19A show that MTBE concentrations detected during August and November 2003 are consistently similar to or lower than those detected during the months of August and November in previous years. The well ID in parentheses after selected wells indicates a well that has been abandoned. Although the replacement wells are not in the exact locations of the abandoned wells, they are presented here as such for comparison purposes.

Because of the large scale required to show maximum MTBE concentrations in Figures 18A and 19A, MTBE fluctuations in the northeastern portion of the plume are not evident. For this reason, downgradient monitoring wells IT-MW-92-38, IT-PZ-9, IT-GMP-17, and IT-GMP-18 were plotted separately in Figures 18B and 19B for the August and November 2003 sampling events, respectively. Unlike other portions of the plume, IT-PZ-9 and IT-GMP-17 have consistently demonstrated increasing concentrations over time. IT-GMP-18, which was added to the monitoring network in August 2000, has not detected MTBE above the detection limit of 0.5 μg/L in 14 consecutive quarters. In August and November 2003, MTBE concentrations increased for wells IT-GMP-17 and IT-PZ-9. However, MTBE concentrations in IT-MW-92-38 continued to decrease in August 2003 (37 μg/L) from the May 2003 event (470 μg/L), but again increased in November 2003 (830 μg/L). The most likely reason for increases in MTBE concentrations in the northeastern portion of the plume are associated with the geology in the area, and was discussed in detail in Attachment 1 of the *Annual Site Status Report (for the Year 2001)* (Battelle, 2002c)

3.6.6 Mass Estimates. Table 9 provides dissolved MTBE and benzene mass estimates calculated for each quarterly monitoring event since May 1998 for benzene and November 1998 for MTBE. The data are presented by year so that seasonal variations over time also can be observed. Note that although the mass estimate calculations are made consistently every quarter, changes in MTBE mass occur when the monitoring well network is modified (i.e., well abandonment, replacement, or additional installation) because dissolved mass is estimated from the wells being monitored. Because some wells that were historically sampled and included in the mass estimates were not sampled in the August 2003 event as a result of the revised monitoring requirements (refer to Table 12 of the *Annual Site Status Report (for the Year 2002)* (Battelle, 2003a), mass estimates were not calculated. Mass estimates were, however, calculated in the November 2003 sampling event as all wells were sampled according to the revised monitoring requirements. The dissolved mass estimate of 0.03 kg for benzene in November 2003 was less than the estimated mass of 0.05 kg for May 2003, and also less than mass estimates for previous November sampling events (Table 9). The MTBE mass estimate for November 2003 remained consistent with the May 2003 sampling event and the previous November 2002 sampling event. Although a general decreasing trend in mass has been observed at the site, some variations (i.e., increases) have been observed periodically due to seasonal variations. In addition, variation in mass estimates can be attributed to the use of the computer software program, Earthvision™ , which is used to estimate mass. The methodology used by the software program to estimate mass, is significantly affected by the volume of water present in the saturated zone; therefore, MTBE mass estimates may be artificially inflated at times because water elevations are higher in areas of greater concentration, rather than concentration differences that actually exist within the wells.

3.6.7 Plume Status. Benzene and MTBE plume contour maps for November 2003 are presented in Figures 20 and 21, respectively. Plume contour maps for the August 2003 sampling event are not provided because not all of the wells were sampled this quarter as they were in November 2003. Recall that the sampling of the monitoring network is reduced in the February and August sampling events per RWQCB approved changes presented in Table 13 of the *Annual Site Status Report (for the Year 2001)*. Figures 20 and 21 not only present the benzene and MTBE plume contours for November 2003, but also the concentration data collected during November sampling events in 2001 and 2002. Concentrations of benzene in wells sampled in both August and November 2003 were similar (refer to Appendix D), indicating that the overall shape and downgradient extent of the benzene plumes are similar for both monitoring events. The benzene contour maps for November 2003 (Figure 20) is similar to the last sampling event in which all wells were sampled except for one notable difference. Benzene concentrations in MW-1E have been decreasing, but were nondetect in November 2003, which can likely be attributed to biosparging operation. Figure 20 shows that essentially all the monitoring wells within the extent of the benzene plume have shown decreasing benzene concentrations over the past three years, which indicates that the benzene plume is stable to shrinking over time.

Concentrations of MTBE in wells sampled in both August and November 2003 were similar (refer to Appendix D), indicating that the overall shape and downgradient extent of the MTBE plumes are similar for both monitoring events. The overall shape and downgradient extent of the MTBE plume for November 2003 (Figure 21) is similar to the last sampling event in which all wells were sampled (i.e., the May 2003 sampling event). Figure 21 shows the MTBE data collected during November sampling events in 2001, 2002, and 2003. It is apparent that the biosparging system is having a positive effect within the treatment area. The MTBE concentration detected in MW-M3 was reported at 16,000 μg/L, 12,000 μg/L, and 7,800 μg/L in November of 2001, 2002, and 2003, respectively. The MTBE concentration detected in 957-MW1 was reported at 27,000 μg/L, 14,000 μg/L, and 9,700 μg/L in November of 2001, 2002, and 2003, respectively. This trends are a good indication that the biosparging system is operating successfully.

Note that five additional wells have been included in the contouring of the plume between MW-M3 and MW-M8. Groundwater monitoring results of the performance goal wells, PG-MW1 through PG-MW5, which were installed to monitor the effects of the biosparging system, have been included to better delineate the plume near the Navy's property boundary. MTBE concentrations for these wells for November 2003 ranged from 3,100 to 13,000 μg/L.

Other observations made with respect to particular wells for sampling performed in August and November 2003 are as follows:

- MTBE concentrations in monitoring well MW-3B, located near the Northbay Children's Center complex, remained below the reporting limit of <0.5 μg/L. These data are consistent with the long-term trend of nondetect MTBE concentrations in this well. The MTBE concentration in the other monitoring well located near the Northbay Children's Center, 970-MW3, was above the detection limit of 0.5 μg/L. Throughout 2003, the MTBE concentrations in 970-MW3 were 7.7 μg/L in February, 2.0 μg/L in May, 0.66 μg/L in August, and 5.4 μg/L in November, all of which are below the Basin Plan Water Quality Objective of 13 μg/L. Future data from well 970-MW3 will be carefully monitored.

- The MTBE concentration in IT-GMP-17 continued to increase to 710 μg/L in August 2003, but decreased in November 2003 to and to 630 μg/L. These concentrations, however, are higher than concentrations for the previous year for August and November in IT-GMP-17. For IT-PZ-9, the MTBE concentration has remained relatively consistent over the four quarterly events in 2003; however concentrations are slightly higher than those detected in 2002. The northeastern portion of the MTBE plume will continue to be closely monitored.

- MTBE was detected in MW-M13 at a concentration of 25 μg/L in August 2003 and 33 μg/L in November 2003. This well serves as an MTBE perimeter well and data indicate concentrations of MTBE are increasing over time at this location. The concentrations in MW-M13 are increasing slowly as compared to those in the northeastern edge of the plume because there seems to be a greater tendency for groundwater to flow around Ammo Hill to the east.

3.6.8 Evaluation of Monitored Natural Attenuation of the MTBE Plume on Former HAAF Property Road. Monitored natural attenuation (MNA) (also referred to as intrinsic remediation) relies on naturally occurring processes such as biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization to reduce concentrations in groundwater. Because a biosparging system has been installed to contain and treat the MTBE plume on currently Navy-owned property (i.e., property south of the railroad tracks), the focus here is on the portion of the MTBE plume that is north of State Access Road (Figure 21). Evaluation of MNA for the northern portion of the plume includes discussion of MTBE concentration versus time trends at 41 sampling locations north of Navy-owned property. The 41 wells located north of Navy-owned property are identified on Table 1 under the location heading, "Development area north of Navy property." Appendix F contains MTBE concentration versus time plots for all of these wells in addition to wells located south of State Access Road; however, only the wells located north of State Access road are discussed below.

Review of the MTBE concentration versus time plots (Appendix F) does not indicate much change since the last review in November 2002. Review of the plots indicates that 16 wells located north of the Navy property boundary (IT-2MW-2, IT-EW-91-1, IT-GMP-18, IT-MW-81S, IT-MW-81D, MW-M11, MW-M12, MW-M15, MW-M16, MW-M18, MW-M19, MW-M24, MW-M25D, MW-M27D, PZ-3, and PZ-4), primarily located on the outer edges of the plume, have remained either at concentrations below detection limits or at very low, but consistent, levels since 1999. In addition, 8 wells (IT-1MW-

4A, IT-2MW-1, MW-M17, MW-M20D, MW-M21, MW-M22, MW-M23, and PZ-1) have shown a decreasing trend in MTBE concentration since 1999. These wells are primarily located within the upgradient half of the northern portion of the MTBE plume. The remaining wells north of the Navy property boundary (IT-GMP-15, IT-GMP-16, IT-GMP-17, IT-MW-92-38, IT-MW-92-39, IT-PZ-5, IT-PZ-7, IT-PZ-9, MW-M13, MW-M14S, MW-M14D, MW-M26S, MW-26D, and MW-M8), which are primarily located within the downgradient portion of the MTBE plume, show increasing concentrations of MTBE. Thus, it appears the natural attenuation processes governing the majority of the MTBE plume are being slightly overcome by advection in the areas of increasing concentrations. These increasing concentrations, however, are not adversely impacting human health or the environment and are minor compared to the decreases in MTBE concentrations found near the former source areas and along the centerline of the entire plume as shown on Figure 19A. It is expected that biosparging operation on Navy property will have a beneficial effect on MTBE concentrations to the north as treated groundwater is allowed time to travel downgradient.

Overall, the downgradient extent of the MTBE plume north of State Access Road has remained relatively stable, but some fluctuations of MTBE concentrations continue to be observed within the plume. Because it is too soon to determine the actual effects that the biosparging system will have on the MNA of the northern portion of the MTBE plume, it is recommended that monitoring continue as planned and MNA be reevaluated in this portion of the Site and reported on in future site status reports.

Section 4.0: SURFACE WATER MONITORING

The following subsections discuss surface water sampling that was conducted at five locations in and around Pacheco Creek in August and November 2003. The August and November 2003 quarterly monitoring events represent the fourteenth and fifteenth quarterly surface water monitoring events.

4.1 Analytical Program

All surface water samples were analyzed for BTEX and MTBE by EPA Method 8260B (gas chromatography/mass spectrometry [GC/MS]). The decision criteria and objectives for sampling locations were presented in Table 4 of the *Groundwater Monitoring Plan* (Battelle, 2000a) and are presented as revised in Table 10. Analytical methods and relevant sampling information are summarized in Table 2. Laboratory PQLs for analytes based on clean matrices are listed in Table 3.

4.2 Sampling

Samples were collected in accordance with the procedures described in the *Groundwater Monitoring Plan* (Battelle, 2000a). The locations where surface water samples were collected during this quarterly monitoring event are shown on Figure 22. These locations include one sample collected upstream of the Site, two samples within the area of dissolved MTBE in underlying groundwater, and two downstream samples (one at the edge and one approximately 1,500 ft downstream of the edge of the extent of dissolved MTBE in underlying groundwater). Figure 23 shows the locations selected and sampled to determine whether a source of MTBE exists in water originating from an individual culvert that enters the creek in this area.

During surface water sample collection, the depth to surface water was measured and recorded at one upstream and one downstream location (see Appendix C). Surface water samples were collected directly into volatile organic analysis (VOA) vials and acidified with HCl for preservation. Immediately following sample collection, VOA vials were maintained at 4°C until shipment and receipt by the analytical laboratory. Copies of the laboratory analytical reports and sampling log sheets (in addition to all pertinent surface water sampling information) are provided in Appendix C.

4.3 Deviations from the Monitoring Plan

PC-SW-CE is the only individual culvert location that is to be sampled. Written approval to discontinue sampling the other three locations (PC-SW-C1, PC-SW-C2, PC-SW-CW) was received from the RWQCB on July 24, 2002. This change is reflected in Table 10. Depth of surface water and flow measurements will be continued at these three locations, as requested by the RWQCB.

An additional surface water sampling location identified as PC-SW-5 (Figure 22) was added to the sampling protocol in the February 2001 monitoring event. The objective of this sampling location was to determine the surface water/groundwater interaction in this area of the Site. The location was selected next to existing monitoring well IT-2MW-1, so that surface water and groundwater concentrations of MTBE can be compared (Figure 24).

4.4 Summary of Findings

This section provides a summary of findings for the August and November 2003 surface water sampling events. Tabulated results of the cumulative surface water analytical data are provided in

Appendix D along with the cumulative groundwater analytical data. Copies of original laboratory data sheets from the August and November 2003 surface water monitoring events are provided in Appendix C.

4.4.1 Surface Water Results. Figures 22 and 23 provide a comprehensive list of MTBE concentrations detected in Pacheco Creek at all sampling locations during each quarterly monitoring event. A cumulative summary of the surface water sampling results for gasoline constituents of concern at regularly sampled locations is provided in Table 11. Concentrations of MTBE remained below detection limits in PC-SW-1 for the August 2003 sampling event, but MTBE was detected for the first time in PC-SW-1 in November 2003. Figure 22 shows that MTBE has not been present upstream of the Site at location PC-SW-1 in Pacheco Creek during any previous quarterly sampling events (also see Table 11). Note that the recent detection at the upstream surface water sampling location is not a result of conditions at the Site. In all likelihood it is probably a result of construction activities occurring in the area south of the Site. Quarterly sampling will continue at the upstream location to determine if there is an observable trend in MTBE concentrations.

MTBE concentrations detected at PC-SW-2, located immediately downstream of several culvert outfalls, remained below detection limits in August and November 2003. For both the August and November 2003 sampling events, MTBE concentrations at PC-SW-5 were below detection limits of 0.50 μg/L. MTBE concentrations at PC-SW-3 were 4 μg/L and 8.9 μg/L for August and November 2003, respectively. The MTBE concentrations at PC-SW-4 in August and November 2003 were 1.3 μg/L and 1.2 μg/L, respectively. The MTBE concentrations detected in the current sampling event are well below the MTBE interim water quality objective of 66,000 μg/L recommended by RWQCB (1998) for the protection of freshwater organisms.

Surface water sampling performed during this quarterly event in the area of the North Hamilton Parkway Bridge (see Figure 23) was conducted to determine whether MTBE concentrations detected in the surface water could be associated with individual culvert outfalls entering Pacheco Creek. MTBE has only been detected at one culvert outfall (PC-SW-CE). The concentrations of MTBE from PC-SW-CE for the August and November 2003 sampling event were below the detection limit of 0.5 μg/L, a significant decrease from the 300 μg/L detected in the May 2003 event.

In order to assess the surface water-groundwater interaction near PC-SW-5, comparisons of MTBE concentrations at PC-SW-5 and in IT-2MW-1 were made (Figure 24). Figure 24 illustrates MTBE concentrations measured in Pacheco Creek at PC-SW-5 and in the nearby monitoring well, IT-2MW-1, over 10 quarters of monitoring data. A comparison of MTBE concentrations in surface water and the nearby monitoring well does not provide clear evidence of surface water-groundwater interaction. Concentrations of MTBE in surface water and groundwater have varied over the quarters and have been at times significantly different from each other. The groundwater-surface water interaction is likely limited by the concrete lining of Pacheco Creek and the MTBE concentrations in surface water are more likely affected by the effluent from the eastern culvert outlet (PC-SW-CE), rather than groundwater conditions.

Section 5.0: BIOSPARGING SYSTEM ACTIVITIES

Routine operation and monitoring of the biosparging system was performed from June 2003 through November 2003 as described in the *Final Remedial Design and Work Plan* (Battelle, 2002a). Activities included collecting field measurements, soil-gas samples, and groundwater samples. A description of these activities conducted from June through November 2003 is provided in this section. Previous biosparging activities were summarized in technical monthly reports that were forwarded to the RWQCB and other interested parties on October 3, November 6, and December 10, 2002 and the Semiannual Site Status Report (for the Months February and May 2003) submitted on August 11, 2003 (Battelle, 2003b).

5.1 System Operation

The biosparging system operated normally from June to November 2003. Field measurements consisting of system operational parameters and groundwater field parameters were collected on a monthly basis in accordance with the *Final Remedial Design and Work Plan* (Battelle, 2002a). Appendix G contains the observations on the well purge and maintenance logs for the performance well sampling events. Appendix H contains the laboratory QC summary reports and analytical data for samples collected from both the performance wells and soil gas monitoring probes are provided in Appendix I.

5.1.1 System Operational Parameters. System operational parameters that were measured included sparging flowrates and injection pressures for each sparging well. In general, the sparging flowrates ranged from 2 to 6 cubic feet per minute (cfm), which is the design specification range of the biosparging system outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a). The flowrates remained fairly steady from June through November 2003; however, if flowrates were found to have increased above 6 cfm, they were adjusted down to below 6 cfm.

System operation was changed to a "pulsing" mode at the end of September 2003 to try and increase the treatment efficiency. Air flow to the individual biosparging injection wells is controlled at 5 separate control panels, or banks located around the Site. The "pulsing" mode of operation means approximately 3 of 5 banks are operating within the design range injection rates (i.e., 2-6 cfm) for two weeks while 2 of the banks are shutdown. Following two weeks of operation, air flow is rotated to 3 different banks of injection wells. The rotation of banks continues on a two week schedule unless the Navy identifies another schedule that might better optimize system operation. The objective of the "pulsed" operation is to introduce air in a manner that differs from previous operations, such that subsurface mixing is promoted and additional MTBE is degraded.

5.1.2 Groundwater Field Parameters. Groundwater field parameters consisted of groundwater elevation and dissolved oxygen (DO) measurements in 18 monitoring wells located within the biosparging treatment area (see Appendix I). Most groundwater elevations decreased slightly from June to November 2003 as a result of the dry season that occurs during the summer months. Overall the biosparging system has not effected groundwater elevations in such a way that would change the groundwater flow direction within the biosparging treatment area.

The data provided in Appendix I indicate that DO levels in performance monitoring wells located near the biosparging treatment area (PG-MW1 through -MW5 and MW-M3) have decreased since June 2003, but are still above the 1.0 mg/L threshold that ensures microbial reactions will not be oxygen-limited (Dupont et al., 1998). Slight increases in DO levels are evident in most wells within the biosparging treatment area since the system was started in September 2002. Note that DO measurements during November 2002 were collected using a different probe and should not be considered when evaluating overall trends in DO concentrations. In December 2002, the Navy began collecting DO measurements using the same meter and procedure that is followed during quarterly groundwater monitoring events.

5.2 Soil-Gas Sampling Results

Soil-gas samples were collected according to the schedule in the *Final Remedial Design and Work Plan* (Battelle, 2002a). Table 12 presents the identification labels for each type of soil-gas monitoring probe. Figure 25 contains a site map showing the location of each soil-gas monitoring probe.

5.2.1 Laboratory Analytical Soil-Gas Measurements. Laboratory samples of soil-gas were collected from seven (7) shallow soil-gas monitoring probes, three (3) deep soil-gas monitoring probes, eight (8) system monitoring soil-gas probes, and two (2) RWQCB-requested quarterly soil-gas monitoring probes according to the schedule presented in Table 13. The sampling procedure followed for collecting soil-gas samples for laboratory analysis was consistent with that used to collect soil-gas samples for the *Final Revised Risk Assessment* (Battelle, 2001a). Duplicate samples were collected for QA/QC purposes from the entire group of soil-gas samples at a rate of 10% during each sampling event. All laboratory samples were analyzed for BTEX, MTBE, 1,2,4-TMB, 1,3,5-TMB, isopropylbenzene, *n*-propylbenzene, and *sec*-butylbenzene.

Laboratory samples of soil-gas were collected from the seven (7) shallow soil-gas monitoring probes consistent with the sampling schedule outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a) and on the dates presented in Table 13. The laboratory results indicate that threshold levels as presented in Table 5 of the *Final Remedial Design and Work Plan* (Battelle, 2002a) were exceeded in one (1) shallow soil-gas monitoring probes (SG-21-3) during the June through November 2003 sampling events. The risk associated with each exceedance was determined using the DTSC risk models, which were consistent with the 30-year residential scenario considered in the *Final Revised Risk Assessment* (Battelle, 2001a). For each exceedance, the total cancer risk did not exceed 1E-06 and the noncancer hazard index did not exceed 1.0. Laboratory results for the shallow soil-gas monitoring probes are provided in Appendix I.

Gasoline constituent concentrations at all of the shallow soil-gas sampling locations except SG-21-3 have been stable at low-level parts per billion or non-detect concentrations between June and November 2003. Concentrations seem to have stabilized more than they were during the early stages of system operation. The MTBE concentration at SG-21-3 is the single outlier to the stable trend. MTBE was detected at 1,283 ppb at SG-21-3 in June 2003. Concentrations increased to 1,427 ppb in July, and then decreased to about 967 ppb in August 2003. However, in September 2003 the MTBE concentration at SG-21-3 dropped to 7 ppb, and in November, MTBE was below 0.3 ppb. In November, MTBE increased to 1,341 ppb. Some minor variations in concentrations would be expected even without biosparging operations because the soil-gas analyses are highly sensitive, and can detect concentrations on the order of 0.3 ppb. In addition, seasonal fluctuations such as decreased rainfall during the summer months certainly have an effect on conditions in shallow soil-gas. The important point is that the Navy has conducted monthly sampling in accordance with the *Final Remedial Design and Work Plan* (Battelle, 2002a), and the results of that sampling indicate that the area is safe for students and faculty at the Northbay Children's Center and Novato Charter School. The Navy will continue with the aggressive monthly shallow soil-gas sampling and confirm that there is no unacceptable risk to these nearby receptors during any period of biosparging system operation.

Laboratory samples of soil-gas were collected from the three (3) deep soil-gas monitoring probes consistent with the sampling schedule outlined in the *Final Remedial Design and Work Plan*

(Battelle, 2002a) and on the dates presented in Table 13. Laboratory results for the three (3) deep soil-gas monitoring probes are summarized in Appendix I. The results indicate that nearly all of the gasoline constituents have decreased and remain well below baseline levels after system startup.

Laboratory samples of soil-gas were collected from the four (4) multilevel system monitoring soil-gas probes consistent with the sampling schedule outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a) and on the dates presented in Table 13. The laboratory results for the system monitoring soil-gas probes show that essentially all of gasoline constituent concentrations have remained below baseline levels since system startup (see Appendix I). These data indicate that significant hydrocarbons are not being added to the vadose zone within the treatment area through volatilization from the saturated zone.

Laboratory samples of soil-gas were collected from the two (2) RWQCB-requested quarterly monitoring probes in June and September 2003 consistent with the sampling schedule outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a). Laboratory results from the quarterly soil-gas monitoring probes are provided in Appendix I. The laboratory results indicate all gasoline constituent concentrations except MTBE at SG-25-3 were at or below their respective baseline levels. Between the June and September sampling events, the concentration of MTBE in SG-25-3 declined from 18.78 ppbv to 6.93 ppbv. The measured concentrations in the RWQCB-requested quarterly monitoring probes do not constitute an unacceptable risk based on the DTSC risk models.

5.2.2 Field Soil-Gas Measurements. Soil-gas field parameters, consisting of measurements for volatile organic compounds (VOCs), oxygen, and carbon dioxide, were collected for shallow monitoring, deep monitoring, and system monitoring purposes. These data were collected to track changes in subsurface conditions caused by biosparging system operation and as indicators of biodegradation. Field measurements were made at the soil-gas monitoring probes to correspond with the collection of soil-gas samples for laboratory analysis. In instances where the sampling schedule did not require soil-gas samples to be collected for laboratory analysis, field measurements were collected from those soil-gas probes to monitor the oxygen, carbon dioxide, and VOC levels. The results of the soil-gas field measurements are presented in Appendix I.

The results indicate that oxygen and carbon dioxide levels remained relatively steady from June through November in the shallow and deep soil-gas monitoring probes. VOC concentrations remained low and steady in all of the shallow and deep soil-gas monitoring probes (see Appendix I; note the difference in scale among the graphs for VOC concentrations). These trends are consistent with the expected behavior of subsurface conditions during biosparging operation.

Field measurements were made at the four (4) multilevel system monitoring soil-gas probes consistent with the monthly schedule as outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a). The results of the soil-gas field measurements for the four (4) multilevel monitoring probes and for the RWQCB-requested quarterly points SG-19-3 and SG-25-3 are presented in Appendix I. In general, oxygen levels appear to have reached steady state at approximately 21% following the initial increasing trend seen soon after system startup. Carbon dioxide levels have remained low at the system monitoring probes. VOC concentrations remained low and steady in all of the multilevel system monitoring soil-gas probes from June to November (see Appendix I; note the difference in scale among the graphs for VOC concentrations). These trends are consistent with the expected behavior of subsurface conditions during biosparging operation.

5.3 Performance Goal Groundwater Sampling Results

Laboratory samples of groundwater were collected from eight (8) performance goal monitoring wells on a monthly basis from June to November 2003. These groundwater sampling events were conducted approximately nine through fourteen (9-14) months after system startup and are consistent with the monthly sampling schedule outlined in the *Final Remedial Design and Work Plan* (Battelle, 2002a). One (1) duplicate sample was collected during each sampling event for QA/QC purposes. The laboratory samples were analyzed for BTEX, MTBE, and MTBE degradation products including TBA, TBF, and acetone. Baseline groundwater samples were collected in the eight (8) performance goal monitoring wells on June 23-24, 2002, for laboratory analysis. A complete listing of laboratory results is provided in Appendix I. Table 14 lists the laboratory results for MTBE concentrations in performance goal monitoring wells before and during biosparging system operation. Figure 26 is a site map showing the locations of performance goal monitoring wells PG-MW1 through PG-MW5, MW-M3, MW-M9, and MW-M10.

The laboratory results indicate that MTBE concentrations have decreased in all performance wells since the baseline sampling event. From June to November 2003, concentrations of MTBE decreased in two (2) wells and increased in six (6) wells. The maximum overall MTBE concentration decrease since system startup was at PG-MW4 from 14,500 µg/L to 3,100 µg/L, which constitutes a 79 % decrease.

Figure 27 shows a plot of the actual versus expected trends in the average MTBE concentration of the performance goal monitoring wells. An average MTBE concentration of 4,963 µg/L existed in the performance goal monitoring wells in November 2003. The average MTBE concentration in the performance goal monitoring wells prior to initiating the biosparging system was 12,951 µg/L. The reduction observed over fourteen months of system operation constitutes a 62% decrease in the average MTBE concentration across all performance goal monitoring wells. One of the main performance goals of the biosparging system is to reduce the average MTBE concentration in the performance goal monitoring wells by 95% to 99%. Figure 27 shows that concentrations have not decreased as rapidly as expected. However, it can also be seen in Figure 27 that concentrations seem to decrease more rapidly during the rainy season (December through March). It seems that the biosparging system was only marginally effective at treating MTBE over the dry months of June through November. The MTBE concentrations leveled off, and slightly increased over the summer. This leveling behavior might be due to the decreased thickness of water in the saturated zone during the dry season of the year. As air continues to be injected by the biosparging system there is less water for it to come into contact with because a thinner saturated zone exists. The decrease in the air to water contact ratio results in less effective MTBE treatment within the saturated zone.

It is important to note that the actual average MTBE concentration in performance goal monitoring wells (12,951 µg/L) was well below 30,000 µg/L, which was the assumed average concentration in the *Final Corrective Action Plan* (Battelle, 2002b) and *Final Remedial Design and Work Plan* (Battelle, 2002a). Because the actual average concentration was much lower than the assumed concentration, it can be expected that the trend of concentration decreases is not as rapid. Another noteworthy point is that some of the performance goal monitoring wells (e.g., PG-MW1 and PG-MW5) are installed in intervals that are in tighter soils, outside the preferential flowpath that has been observed at the site. The treatment efficiency of the biosparging system will not be completely represented because the areas these subject wells are installed in will reach a point of diffusion-limited remediation prior to those wells installed within the preferential flowpath.

In addition to monthly sampling of the performance goal monitoring wells, the quarterly groundwater monitoring program has commenced in the area of the biosparging system. A visual interpretation of the biosparging treatment effectiveness can be deduced from the MTBE plume contour maps that are shown in Figure 28. The hot-spot of MTBE (concentrations >10,000 μg/L) located on currently-owned Navy property is shown to exist before the biosparging system was started, and following two months of system operation. During the August and November 2003 sampling events the MTBE hot-spot is shown to be greatly reduced indicating that the biosparging is operating as expected. The Navy anticipated that the hot-spot would begin to collapse on itself after the biosparging system was initiated.

BTEX and acetone in the performance goal monitoring wells remained below the detection limit. Over the past six months of system operation, TBA concentrations ranging between 26 μg/L and 1,900 μg/L were detected in the six (6) performance goal monitoring wells exhibiting the highest MTBE concentrations; however, the detections do not indicate TBA accumulation because the concentrations seem to disappear rapidly. Concentrations of TBA during November 2003 ranged from 26 μg/L to 60 μg/L. TBF was detected in one performance goal monitoring well (MW-M3), but at very low concentrations, which also indicates no accumulation.

5.4 Summary of Biosparging System Operation Results

Based on the data collected since system startup, the biosparging system is operating as expected. Biodegradation that is likely occurring within the saturated zone and deeper portions of the vadose zone is sufficiently controlling gasoline constituents in the subsurface. MTBE concentrations in groundwater are decreasing with some production (yet no significant accumulation) of degradation byproducts over the first fourteen (14) months of system operation. Significant decreases in MTBE concentrations exist in some performance monitoring wells (MW-M3, MW-M9, MW-M10, PG-MW2, PG-MW3, and PG-MW4). The laboratory results and field measurements of gasoline constituents in soil gas indicate that significant hydrocarbons are not being added to the shallow vadose zone within the treatment area or along pathways to nearby receptors.

Section 6.0: ANNUAL MONITORING PROGRAM EVALUATION AND OPTIMIZATION

The following subsections present recommendations for monitoring program optimization that are based on decision criteria discussed in Section 5.0 of the *Groundwater Monitoring Plan* (Battelle, 2000a). Modifications to the monitoring program (i.e., changes in sampling frequency, network, or well abandonment) are discussed on an annual basis. This section discusses the evaluation of monitoring program optimization including decision criteria for sampling frequency and well abandonment and the approach to sampling network evaluation/modification.

6.1 Sampling Frequency

The criteria for the evaluation of sampling frequency are presented in the decision diagram in Figure 5 of the *Groundwater Monitoring Plan* (Battelle, 2000a). As discussed in Section 5.0 of the *Annual Site Status Report (for the Year 2002)* (Battelle, 2003a), the sampling frequency for the following wells has been decreased from quarterly to semiannual monitoring: MW-5A, MW-4B, MW-M25D, MW-6B, IT-MW-81S, MW-M24, and MW-M27D. In many cases, these wells had an established concentration trend that suggested that data objectives for the well could be met with less frequent monitoring. Semiannual sampling performed in May 2003 and November 2003 indicated that concentrations remained within the expected ranges for the wells with reduced sampling frequency; therefore, it is recommended that these wells continue to be sampled on a semiannual basis until the next annual evaluation. The sampling frequency for the following wells was decreased from semiannually to annual monitoring: MW-M20S, MW-M25S, MW-M26S, and MW-M27S. Annual sampling in November 2003 showed that concentrations for these wells remained within expectations, so it is recommended that these wells continue to be sampled on an annual basis. During the next annual evaluation, the remaining wells that are currently sampled on a semiannual basis will be reassessed and if concentrations continue to follow existing trends, the Navy may propose that some wells be monitored on an annual basis provided that data objectives can continue to be met.

The Navy proposes that monitoring continue on a quarterly basis for most wells over the next annual cycle due to the importance of continual monitoring of remedial actions discussed in the *Final Corrective Action Plan for Groundwater* (Battelle, 2002b). At the next annual evaluation cycle, the sampling frequency will be reevaluated based on remedial objectives and data requirements. However, at this time some wells are recommended for reduced sampling frequency based on the decision diagram presented in Figure 5 of the *Groundwater Monitoring Plan* (Battelle, 2000a). The decision diagram was used in conjunction with Table 1 (revised Table 3 of the *Groundwater Monitoring Plan* [Battelle, 2000a]) to assess data objectives from each well. Each well included in the monitoring network was evaluated using the decision diagram to determine if the data objectives for a particular well could be met with less frequent monitoring. Trends in the concentration of gasoline constituents (namely MTBE) over time were analyzed by plotting the MTBE concentration versus time or by reviewing the cumulative concentration data provided in Appendix D. These plots and data aided in identifying wells with increasing, decreasing, or stable trends in BTEX and MTBE concentrations. Plots showing the MTBE concentration over time in each well included in the monitoring network are provided in Appendix F. Any wells showing fluctuating MTBE and/or BTEX concentrations over time were not recommended for less frequent sampling because concentration trends were not yet clearly established. Some wells with decreasing concentration trends were not recommended for less frequent sampling because they were located near areas of interest at the site. Examples of these areas of interest include the Hamilton Meadows Subdivision, Pacheco Creek, the northeastern leading edge of the MTBE plume, the area of remedial actions, and the Northbay Children's Center complex and Novato Charter School located east of C Street. Table 15 presents a comprehensive list of wells that are recommended for changes in sampling frequency. The data objective of each well listed in Table 15 is also provided. For those wells recommended for semiannual and annual monitoring, sampling will be performed semiannually during May and November and annually during November events, respectively, pending agreement from the RWQCB. The following subsections present a detailed summary of the sampling frequency evaluation based on the decision criteria required for the groundwater monitoring network (see Table 15). Please refer to the site map provided in Figure 21 for exact locations of monitoring wells being discussed during the evaluation in the following subsections.

6.1.1 Area A (970 Source Area) Wells. Monitoring wells 970-MW1, MW-5A, MW-6A, MW-1A, and MW-7A are included in the network to assess MTBE and BTEX concentration trends near the former UST 970 source area (Table 1). All of these wells are sampled to identify the likelihood that a source still exists near the former 970 UST and they show overall stable to decreasing MTBE and BTEX concentrations. However, some fluctuations in MTBE concentrations are evident in well MW-7A (see Appendix F). Therefore, continued quarterly monitoring is recommended for this well until the fluctuations in concentration can be further assessed. The MTBE concentrations at MW-6A are lower than those in MW-7A, and they have shown a decreasing trend over time; therefore, it is proposed that the sampling frequency at MW-6A be decreased from quarterly to semiannually. The sampling frequency for monitoring well MW-5A was decreased from quarterly to semiannually during the last annual cycle; it is recommended that this well continue to be sampled on a semiannual basis because concentrations over the past year have remained stable. By implementing these recommendations and proposed changes, the data objectives of the wells will not be compromised.

6.1.2 Area D (957 Source Area) Wells. Monitoring wells MW-1D, MP-1D, 957-MW4, and 957-MW3 are included in the network to assess MTBE and BTEX concentration trends in the former UST 957 source area (Table 1). These wells are located in an area of the Site that is being treated by the biosparging system (Battelle, 2002d); therefore, these wells will continue to be sampled on a quarterly basis to monitor any changes in gasoline constituent concentrations near the former UST 957 during biosparging system operation.

6.1.3 Area B Wells. Monitoring wells MW-4B, MW-1B, 970-MW4, and MW-3B are included in the network as a transect of wells in Area B to determine whether internal plume migration might be occurring in this area of the Site (Table 1). Each of the transect wells sampled in Area B show decreasing to stable MTBE (see Appendix F) and BTEX concentration trends. It is recommended that MW-3B continue to be sampled on a quarterly basis because it is in close proximity to the Northbay Children's Center located east of C Street. The sampling frequency of MW-4B was decreased from quarterly to semiannual sampling during the last annual assessment; and the sampling frequency of MW-1B and 970-MW4 were reduced during the November 2001 annual assessment. It is recommended that these wells continue to be monitored on a semiannual basis because the data objectives of these wells can continue to be satisfied with the current monitoring frequency.

6.1.4 Property Boundary (State Access Road) Wells. Monitoring wells MW-M1, MW-M10, MW-M9, MW-M8, and MW-M16 are included in the network as a transect of wells near the Navy property boundary to determine whether internal plume migration might be occurring in this area of the Site (Table 1). Monitoring well MW-M10 has shown relatively stable to decreasing MTBE concentrations over time, while MTBE concentrations in MW-M8 and MW-M9 have been fluctuating over time (see Appendix F). BTEX and MTBE have never been detected in MW-M1 and MW-M16 with the exception of a low-level toluene detection (0.84 µg/L) and low level MTBE (0.45J) in MW-M1 during the August 2001 and November 2003 sampling events, respectively, both of which can be attributed to airborne contamination during sample collection (Battelle, 2001b). Because all of the wells included in the property boundary transect are potentially located within the area of influence of the biosparging system, it is recommended that quarterly sampling continue. However, it is proposed that upon biosparging system shutdown, sampling of wells MW-M1 and MW-M16 be reduced to a semiannual basis. The data objectives of these particular wells will not be compromised with a less frequent sampling schedule considering long-term non-detect trends have been well established.

6.1.5 Downgradient MTBE Transect Wells. Monitoring wells IT-2MW-2, IT-1MW-4A, IT-MW-92-38, IT-MW-92-39, and MW-M25 (S and D) are included in the network as a transect of wells located just north of the Hamilton Meadows Subdivision to determine whether internal plume migration might be occurring in this area of the Site (Table 1). MTBE has only been detected once in IT-2MW-2 (at 11 µg/L) during 16 sampling events and has never been detected in MW-M25S or MW-M25D since the well was installed in November 2000. It is recommended that semiannual sampling continue at MW-M25D and IT-2MW-2 because the data objectives of these wells will continue to be met. Decreasing MTBE concentrations between 11 µg/L and 3.9 µg/L have been reported in IT-1MW-4A over the past two years of monitoring; therefore, it is proposed that the sampling frequency be decreased from quarterly to semiannually. By implementing this proposed change the data objective of IT-1MW-4A will not be compromised. MTBE concentrations over time in IT-MW-92-38 and IT-MW-92-39 have been fluctuating and slightly increasing, respectively; therefore, it is recommended that the sampling frequency remain quarterly.

6.1.6 Benzene Plume Perimeter Wells. Monitoring wells NA-0, 970-MW1, 970-MW2, 957-MW1, 957-MW3, 970-MW3, MW-3B, and MW-10A are included in the network to monitor the outer extent of benzene plume (Table 1). A review of the historical data from the wells surrounding the benzene plume indicates that the dissolved plume is very stable to shrinking. Because the benzene plume has been so well defined and quarterly data indicate it is stable or shrinking, wells sampled to track the extent of the benzene plume can be sampled on a semiannual basis and still satisfy their data objectives. However, some of the wells used to monitor the extent of the benzene plume are located near sensitive areas of interest at the Site and call for continued quarterly monitoring. It is proposed that quarterly sampling continue at 957-MW1 and 957-MW3 because these wells are located in the area of influence of the biosparging system. 970-MW3 and MW-3B should also continue to be monitored quarterly because they are located near the Northbay Children's Center. Semiannual sampling has occurred at NA-0, 970-MW1, 970-MW2, and MW-10A, and it is recommended to continue because the data objectives will continue to be met.

6.1.7 MTBE Plume Perimeter Wells. Monitoring wells NA-0, MW-4B, MW-6B, MW-2D, MW-2E, MW-M1, PZ-3, PZ-4, MW-M19, MW-M11, IT-2MW-2, IT-PZ-5, MW-M12, MW-M13, IT-GMP-18, IT-MW-81 (S and D), IT-EW-91-1, MW-M25 (S and D), MW-M24, MW-M16, MW-M2, 970-MW3, and MW-3B are included in the network to monitor the outer extent of MTBE plume (Table 1). The outer extent of the MTBE plume has been carefully tracked for approximately 17 quarters, and while there are some edges of the plume that appear to fluctuate over time (e.g., northeastern leading edge), most of the plume boundaries have been well established. Because the plume boundaries are so well defined, it is possible to reduce sampling frequency for several perimeter wells without sacrificing data objectives. For most wells used to define the MTBE plume boundary where MTBE has never been detected (NA-0, PZ-4, MW-M11, MW-M12, MW-6B, and IT-MW-81S), the sampling frequency has already decreased from quarterly to semiannually, and it is recommended that these wells continue to be sampled semiannually. IT-EW91-1 has shown no MTBE concentrations above detection limits for seventeen consecutive quarters. It is proposed that IT-EW91-1 be sampled on an annual basis because the data objectives will continue to be met if annual confirmation of the MTBE plume extent in the area of this well is performed. The remaining wells are located near areas of interest at the Site (i.e., northeast leading edge, Navy property boundary, or Northbay Children's Center) and will continue to be sampled on a quarterly basis. By implementing these recommendations and proposed changes the data objectives of the wells will not be compromised.

6.1.8 Wells Along the Centerline of the MTBE Plume. Monitoring wells NA-0, NA-1, MW-1A, 970-MW5, MW-4A, 970-MW4, NA-4, NA-6, NA-7, 957-MW4, MW-1E, 957-MW1, MW-M3, MW-M9, PZ-1, IT-MW-92-38, MW-M20 (S and D), MW-M21, MW-M22, MW-M23, IT-PZ-9, IT-GMP-17, and IT-GMP-18 are included in the network to compare MTBE and benzene concentrations along the MTBE plume centerline to risk levels established in the *Tier 3 Risk Based Corrective Action (RBCA) Assessment* (Battelle, 1999) (Table 1). MTBE and benzene risk levels calculated in the *Tier 3 RBCA Assessment* (Battelle, 1999) have not been exceeded at any monitoring wells, including those located along the MTBE plume centerline, since May 1999 and February 2001, respectively. The significance that exceedances of Tier 3 RBCA risk levels have not persisted at the Site is that groundwater conditions do not present an unacceptable risk when considering a 30-year residential scenario. The decreasing trend of MTBE concentrations over time has been most evident in wells located closer to the former UST 970; which allowed the sampling frequencies for MW-1A, 970-MW5, MW-4A, and 970-MW4 (located in Area A or Area B) to be decreased from quarterly to semiannually during the November 2001 assessment. All other wells on the MTBE plume centerline are located near areas of interest at the Site and require quarterly sampling. These areas of interest include the area of influence of the biosparging system, Hamilton Meadows Subdivision, and the northeastern leading edge of the MTBE plume.

6.1.9 Wells Located in the Development Area North of Navy Property. Monitoring wells PZ-1, PZ-3, PZ-4, MW-M11, MW-M15, IT-2MW-1, IT-PZ-5, IT-2MW-2, IT-1MW-4A, IT-MW-92-38, IT-MW-92-39, IT-GMP-15, EW-91-1, MW-M12, IT-PZ-7, MW-M13, IT-PZ-9, IT-GMP-17, MW-M14 (S and D), MW-M17, MW-M18, MW-M19, MW-M20 (S and D), MW-M21, MW-M22, MW-M23, MW-M24, MW-M25 (S and D), MW-M26 (S and D), MW-M27 (S and D), IT-GMP-16, IT-GMP-18, IT-MW-81 (S and D), MW-M8, and MW-M16 are included in the network to compare MTBE concentrations in the vicinity of Hamilton Meadows Subdivisions to risk levels established in the *Tier 3 RBCA Assessment* (Battelle, 1999) (Table 1). As discussed in Section 6.1.8, MTBE and benzene risk levels calculated in the *Tier 3 RBCA Assessment* (Battelle, 1999) have not been exceeded in any Site monitoring wells since May 1999 and February 2001, respectively. Sampling frequency at wells PZ-4, IT-2MW-2, MW-M11, MW-M12, MW-14S, MW-M20S, MW-M25S, MW-M26S, and MW-M27S was decreased from quarterly to semiannually based on recommendations presented in the *Annual Site Status Report* (for the Year 2001) (Battelle, 2002c) and sampling frequency at wells MW-M24 and MW-M25D was decreased from quarterly to semiannually during the last evaluation. There are no recommended changes to the sampling frequency of these wells.

6.1.10 Wells Adjacent to the Northbay Children's Center. Monitoring wells 970-MW3 and MW-3B are included in the network to determine whether MTBE and BTEX might be affecting the Northbay Children's Center complex east of C Street (Table 1). These wells serve as perimeter wells to the MTBE plume adjacent to the Northbay Children's Center complex; therefore, quarterly sampling of the wells will continue.

6.1.11 Pacheco Creek Vicinity Wells. Monitoring wells IT-PZ-5, IT-2MW-2, IT-1MW-4A, IT-2MW-1, MW-M17, and MW-M18 are included in the network to determine whether MTBE in groundwater might be impacting surface water in Pacheco Creek (Table 1). Sampling activities conducted to date indicate that the most likely source of MTBE in Pacheco Creek is a storm sewer outlet located just upstream of the North Hamilton Parkway Bridge.

MW-M18 is the only well sampled in the immediate vicinity of Pacheco Creek that does not show general decreasing concentrations of MTBE over time. MTBE concentrations have been consistently decreasing in IT-1MW-4A, and the well is in close proximity to IT-PZ-5; therefore, it was recommended in Section 5.1.5 that IT-1MW-4A be sampled on a semiannual basis. Because IT-PZ-5 will continue to be sampled quarterly, it is anticipated that the data objectives for IT-1MW-4A will be met through semiannual sampling. IT-2MW-2 is recommended for continued semiannual monitoring.

6.1.12 Bedrock Wells. Monitoring wells MW-2E-BR, MW-M8-BR, MW-M2-BR, MW-9A, and MW-3D are included in the network to assess MTBE and BTEX impacts to groundwater in bedrock at the Site. Constituent concentrations detected in bedrock wells are compared to nearby shallower screened wells to determine whether bedrock in the areas is impacted. Continued testing of the bedrock conditions at the Site is planned during operation of the biosparging system (Battelle, 2002d); therefore, quarterly monitoring of the bedrock wells will be continued at this time.

6.1.13 Former UST 970-3 Tank Pit Excavation Location Well. MW-8A is included in the network to assess MTBE and BTEX concentration trends near the former UST 970 source area. The well has been sampled for thirteen consecutive quarters and MTBE concentrations have fluctuated between 250 and 2,000 μg/L, which does not establish a decreasing or increasing trend but indicates no significant source remains. The well will continue to be monitored on a quarterly basis until concentration trends can be better established.

6.1.14 Nested Well Pairs. Monitoring wells MW-M20 (S and D), MW-M14 (S and D), MW-M25 (S and D), MW-M26 (S and D), and MW-M27 (S and D) are included in the network to determine the vertical distribution of MTBE at the Site (Table 1). Annual sampling of the shallow completions was approved by the RWQCB following the last annual evaluation. During the last annual evaluation, the sampling frequency at MW-M25D and MW-M27D was decreased from quarterly to semiannually. Most nested well pairs within the network have continued to show very comparable concentrations between samples collected from shallow and deep intervals over thirteen quarters of sampling, indicating that MTBE is not being stratified between the upper and lower aquifer zones. However, MW-M14 (S and D) have not shown consistent concentrations over the past several quarters; therefore, it is proposed that monitoring be continued at both the shallow and deep completions on a quarterly basis to determine if stratification of MTBE is occurring at this location. Due to the consistent concentrations in shallow and deep completions at MW-M26, it is proposed that the sampling frequency at MW-M26D be decreased from quarterly to semiannually. MTBE concentrations at this location have been stable to decreasing over time, which will allow the data objectives to be met with less frequent sampling.

6.2 Sampling Network

As stated in Section 5.2 of the *Groundwater Monitoring Plan* (Battelle, 2000a), the monitoring well and surface water network will be evaluated and modified to ensure that data objectives (as presented in Tables 1 and 10 for groundwater and surface water, respectively) are being met.

6.2.1 Groundwater Monitoring Well Network. Proposed modifications to the groundwater monitoring network as originally presented in the *Groundwater Monitoring Plan* (Battelle, 2000a) are as follows:

- Continue monitoring at IT-GMP-16. This well was originally removed from the monitoring network as presented in the *Groundwater Monitoring Plan* (Battelle, 2000a) due to its close proximity to IT-PZ-9 and to their similar MTBE concentrations. However, increasing MTBE concentrations in IT-GMP-16 (and diverging from IT-PZ-9 concentrations) were observed before the well was removed from the network; therefore it was recommended that monitoring be continued at IT-GMP-16.

- Wells installed during Remedial Investigation activities (Battelle, 2001c) will continue to be included in the monitoring well network as operation of the biosparging system continues over the next year.

- Wells installed as a result of additional bedrock investigations (Battelle, 2003a) will be included in the monitoring well network. The wells installed include MW-2E-BR, MW-M2-BR, and MW-M8-BR
- Continue monitoring at IT-GMP-18. This well serves as the new MTBE perimeter monitoring well in the northeast portion of the plume, because MTBE has been detected consistently at IT-GMP-17. Monitoring at IT-GMP-18 has occurred for 14 consecutive quarters through November 2003 without MTBE being detected.
- Monitoring well IT-MW-81 (S and D) has been monitored to provide additional information regarding the northeastern leading edge of the MTBE plume. The shallow and deep intervals of this well have been sampled for eleven quarters since the modification was originally presented in the *Annual Site Status Report (for the Year 2000)* (Battelle, 2001c), and MTBE has not been detected during any of the eleven events. IT-MW-81S is now monitored semiannually (May and November) instead of quarterly. It is recommended that IT-MW-81D continue to be monitored on a quarterly basis.
- Piezometers PZ-10 and PZ-11, which were installed during the Public Benefit Conveyance (PBC) Parcel 2 (east of C Street) Investigation of August 2001, were added to the monitoring network in 2000. These piezometers are located in a relatively dry area of the Site, but they will be checked for groundwater during each quarterly sampling event. If groundwater is present, samples will be collected and analyzed to ensure that the MTBE plume does not impact the area near the Northbay Children's Center east of C Street. Sufficient groundwater was available for sampling in PZ-10 during eight of the nine sampling events since the modification was originally presented in the *Annual Site Status Report (for the Year 2001)* (Battelle, 2002c), and the analytical results indicated MTBE was nondetect. Sufficient groundwater has been available to sample PZ-11 only during the wet season, and analytical results are fluctuating.

6.2.2 Surface Water Monitoring Network. No modifications to the surface water monitoring network as originally presented in the *Groundwater Monitoring Plan* (Battelle, 2000a) and revised in the *Annual Site Status Report (for the Year 2001)* (Battelle, 2002c) are recommended at this time.

6.3 Well Abandonment

The criteria for the evaluation of monitoring wells for potential abandonment are presented in the decision diagram in Figure 6 of the *Groundwater Monitoring Plan* (Battelle, 2000a). Based on these criteria, there are no wells recommended for abandonment.

Section 7.0: CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions drawn from the results of the August and November 2003 groundwater and surface water monitoring activities and recommendations based on the evaluation of the data.

7.1 Conclusions for Groundwater Monitoring

The overall shape and downgradient extent of the benzene and MTBE plumes is similar to the previous reported sampling event in May 2003. Pertinent observations of the results collected during November 2003 are as follows:

- Internal benzene contours of 10 and 100 μg/L showed slight variations between the May and November 2003 monitoring events in the southern, middle, and northern portions of the plume, most likely indicative of seasonal fluctuations and/or effects of the biosparging system that has been in operation since September 2002 (Figure 20).

- The estimated benzene mass for November 2003 (0.03 kg) decreased slightly since the May 2003 sampling event (0.05 kg) and is lower than the benzene mass estimates from November sampling events in the previous three years.

- The estimated MTBE mass remained consistent with the May 2003 sampling event (126 kg), but is slightly higher than the MTBE mass estimates from November sampling events in the previous three years.

- MTBE concentration in monitoring well MW-3B, located near the Northbay Children's Center complex, remained below the reporting limit of <0.5 μg/L. The MTBE concentration in the other well located by the Northbay Children's Center, 970-MW3, remains above detection limits (0.5 μg/L), at concentrations ranging from 0.66 μg/L in August 2003 to 5.4 μg/L in November 2003.

- The MTBE concentration in IT-GMP-17 continues to fluctuate. The MTBE concentration increased from 570 μg/L in May 2003 to 710 μg/L in August and then decreased to 630 μg/L in November 2003.

- The MTBE concentration in MW-M2, located on the eastern perimeter of the plume, decreased significantly from the November 2002 event (370 μg/L) to below the detection limit in February 2003 and remained below the detection limit in May, August, and November 2003.

- The MTBE concentration in MW-M13 was higher in November 2003 (33 μg/L) than in August 2003 (25 μg/L). This well serves as an MTBE perimeter well. As discussed in Section 3.6.7, an increasing concentration trend is evident in this well but it is not pronounced as in wells located near the northeast leading edge of the plume. Future monitoring will continue to track the condition of the well.

- MTBE concentrations for August 2003 in bedrock wells MW-9A and MW-3D were reported at 270 μg/L and 20,000 μg/L, respectively. For November 2003, MTBE concentrations in bedrock wells MW-9A and MW-3D were reported at 150 µg/L and 23,000 µg/L, respectively. The MTBE concentrations in MW-9A have decreased in 2003 compared to sampling events in 2002. For MW-3D, concentrations of MTBE observed in 2003 are fairly consistent with MTBE concentrations observed in 2002. MTBE concentrations in the new bedrock wells that were installed in November 2003 ranged from 0.4 µg/L to 4,700 µg/L. Note that groundwater samples from the new bedrock wells were not collected at the same time as samples from the alluvial wells because the bedrock wells had not yet been installed. Future quarterly monitoring of the bedrock monitoring wells will allow for a more complete understanding of the conditions of groundwater in bedrock.

- All surface water sampling results are well below the interim water quality objective of 66,000 µg/L recommended in 1998 by the RWQCB for the protection of freshwater organisms.

- For the first time since surface water was sampled, analytical results indicate the presence of low levels (2.4 µg/L) of MTBE in Pacheco Creek upstream of the Site (PC-SW-1). This first-time low-level detection at the upstream sampling location can not be attributed to the Navy Site and quarterly monitoring in the future will determine if the concentration persists. MTBE-concentrations at three surface water sampling locations within the area of MTBE-impacted groundwater are relatively low (<0.5 to 9 µg/L) indicating that the surrounding groundwater is not likely contributing significantly to MTBE concentrations in surface water.

7.2 Conclusions for Biosparging Activities

The biosparging system operated normally from June 2003 to December 2003. Results indicate that biodegradation is likely occurring within the saturated zone and deeper portions of the vadose zone, which suggests gasoline constituents in the subsurface are being sufficiently controlled. Pertinent observations of the results obtained between June 2003 and December 2003 are as follows:

- Soil-gas laboratory results for the seven (7) shallow monitoring probes indicate that threshold levels as presented in Table 5 of the *Final Remedial Design and Work Plan* (Battelle, 2002c) were exceeded in one (1) shallow soil-gas monitoring probe (SG-21-3). The risk criteria of 1E-06 for carcinogenic risk and 1.0 for noncarcinogenic hazard were not exceeded.

- Laboratory results of soil gas collected from the three (3) deep soil-gas monitoring probes indicate that nearly all of the gasoline constituents have decreased and remained well below baseline levels after system startup.

- Laboratory results of soil gas collected from the four (4) multilevel system monitoring soil-gas probes indicate that significant hydrocarbons are not being added to the vadose zone within the treatment area through volatilization from the saturated zone.

- Laboratory results of soil gas collected from the two (2) RWQCB-requested quarterly monitoring probes indicate all gasoline constituent concentrations except MTBE at SG-25-3 were at or below their respective baseline levels. The measured concentrations in the RWQCB-requested quarterly monitoring probes do not constitute an unacceptable risk based on the DTSC risk models.

- Laboratory results of groundwater collected from the eight (8) performance goal monitoring wells indicate that MTBE concentrations have decreased in all performance wells since the baseline sampling event. The most notable change has occurred in PG-MW4. The MTBE concentration was 14,500 µg/L in June 2002 and 3,100 µg/L in November 2003; a decrease of 79% since system startup.

7.3 Recommendations

The November 2003 monitoring event constitutes the 23rd quarterly groundwater sampling event performed at the Site over the past 5 years. During this time, a large amount of analytical data has been collected to better understand the behavior of the dissolved gasoline constituent plumes. The monitoring program has been optimized on an annual basis (refer to Section 6.0) to ensure data objectives continue to be met in a cost-effective manner. Recommendations that are suggested for inclusion in the monitoring program starting in February 2004 are as follows:

- Implement the changes to the groundwater monitoring well sampling frequency as discussed in Section 6.1 and summarized in Table 15.
- Continually update the site map to represent Site features for which additional information is obtained.
- Provide an evaluation of MNA for the portion of the MTBE north of the Navy property boundary in future site status reports.

These recommendations will not be incorporated into the monitoring program until the RWQCB has had sufficient time to review them and provide written comment or concurrence.

Section 8.0: FUTURE PLANNED ACTIVITIES

This section describes future activities to be performed in association with Former UST Site 957/970 during the two quarters of December 2003 through May 2004. A semiannual site status report will be distributed in July 2004 to report on activities over the next two quarters, in accordance with Task 9 of the RWQCB Order No. 00-064. Section 7.1 identifies activities to be performed in the field, and Section 7.2 includes all other activities not specifically associated with the above items.

8.1 Fieldwork

- Continue to perform quarterly groundwater and surface water sampling in February and May 2004 in accordance with the *Groundwater Water Monitoring Plan* (Battelle, 2000a). Sampling will be conducted according to the protocol presented in Tables 5 and 10 for groundwater and surface water, respectively, if concurrence is received from the RWQCB.
- Perform routine operations and monitoring of the biosparging system as described in the *Final Remedial Design and Work Plan* (Battelle, 2002c). Some additional adjustments to system operation will likely be made to promote more cost-effective treatment efficiency before reaching a point of asymptotic removal.

8.2 Other Activities

- Continue to address regulatory and public concerns regarding biosparging system operation and property transfer issues.

Section 9.0: REFERENCES

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FIGURES

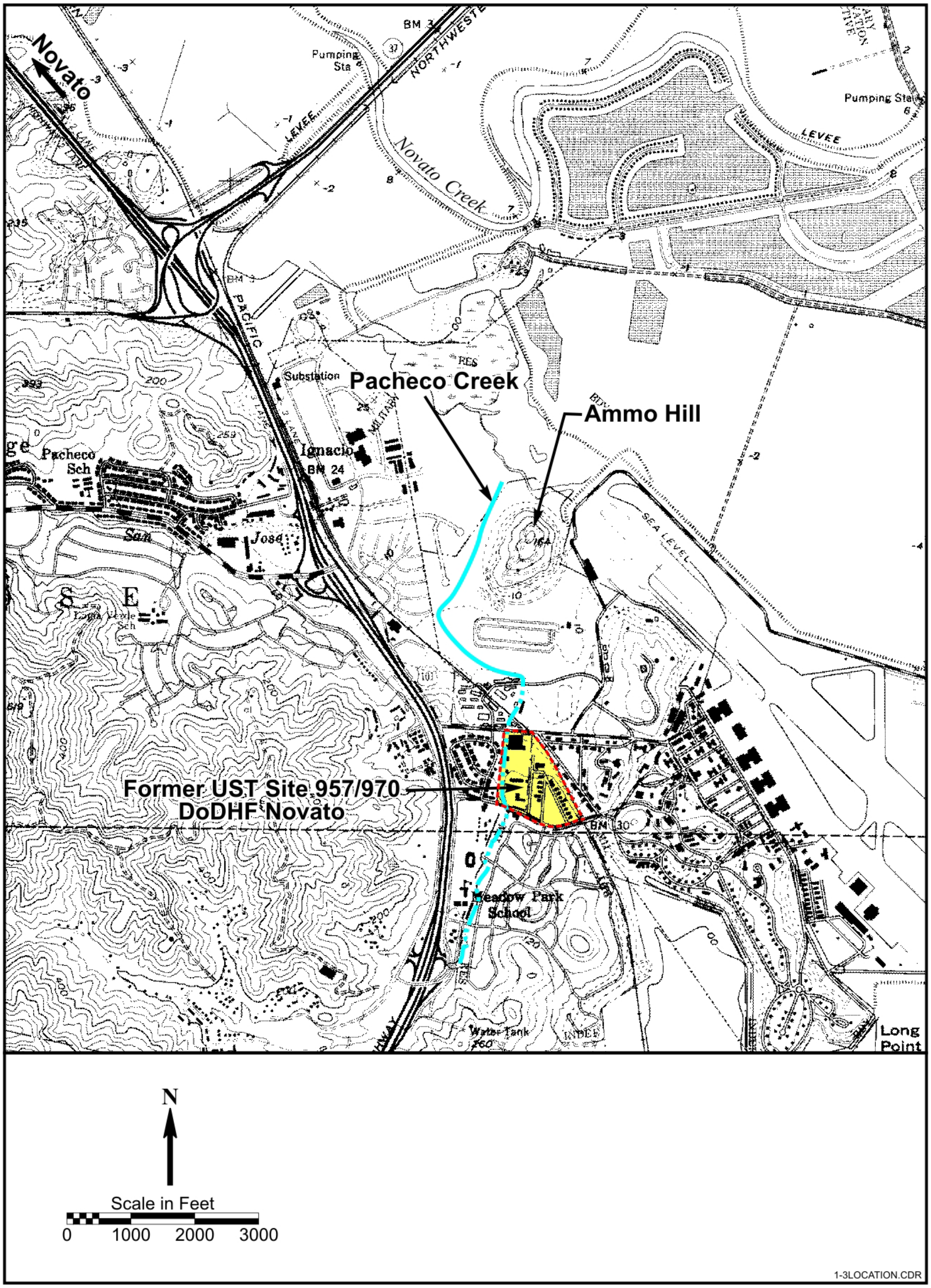


Figure 1. Site Location Map

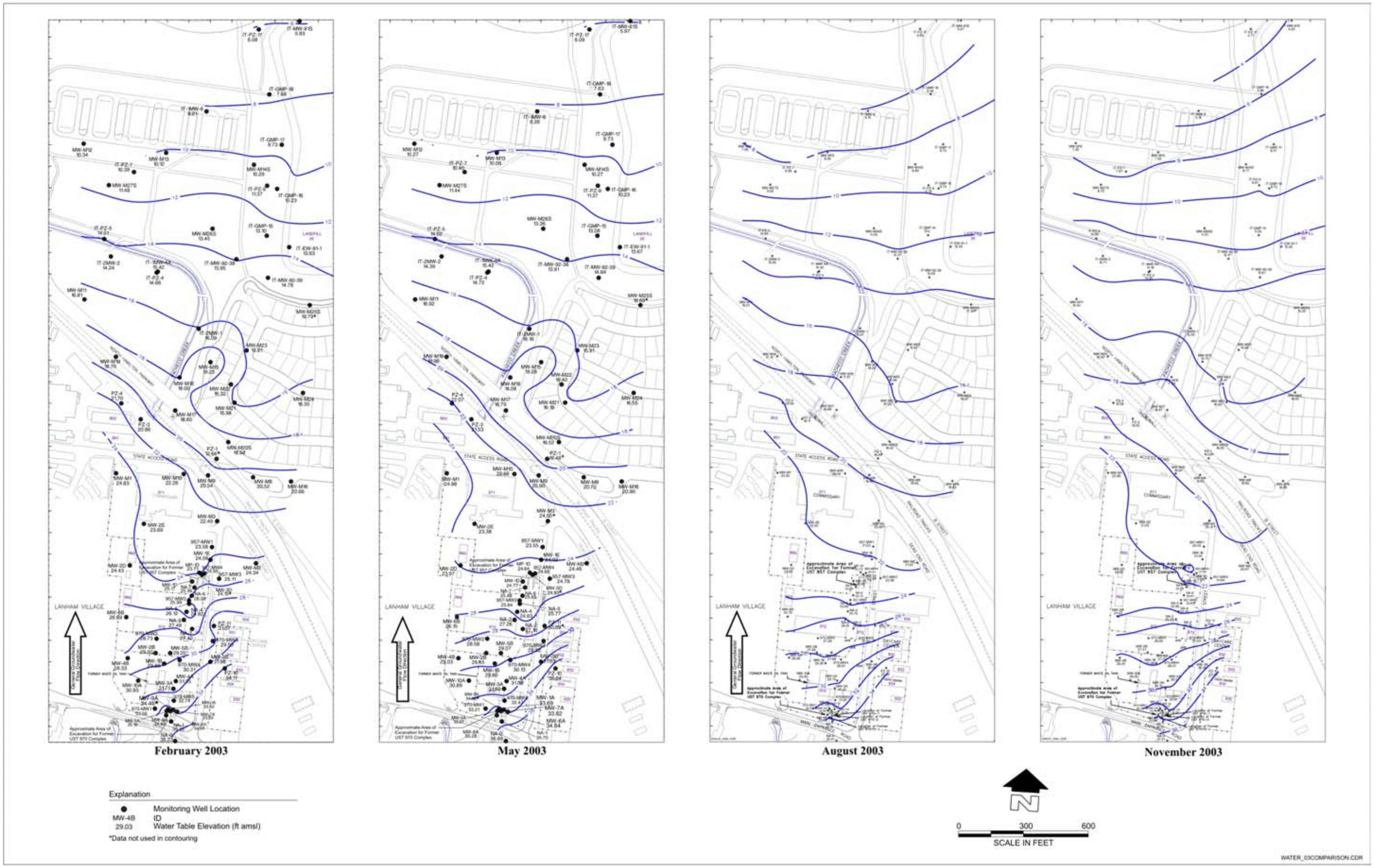


Figure 2. Comparison of Potentiometric Maps for Monitoring Events in 2003

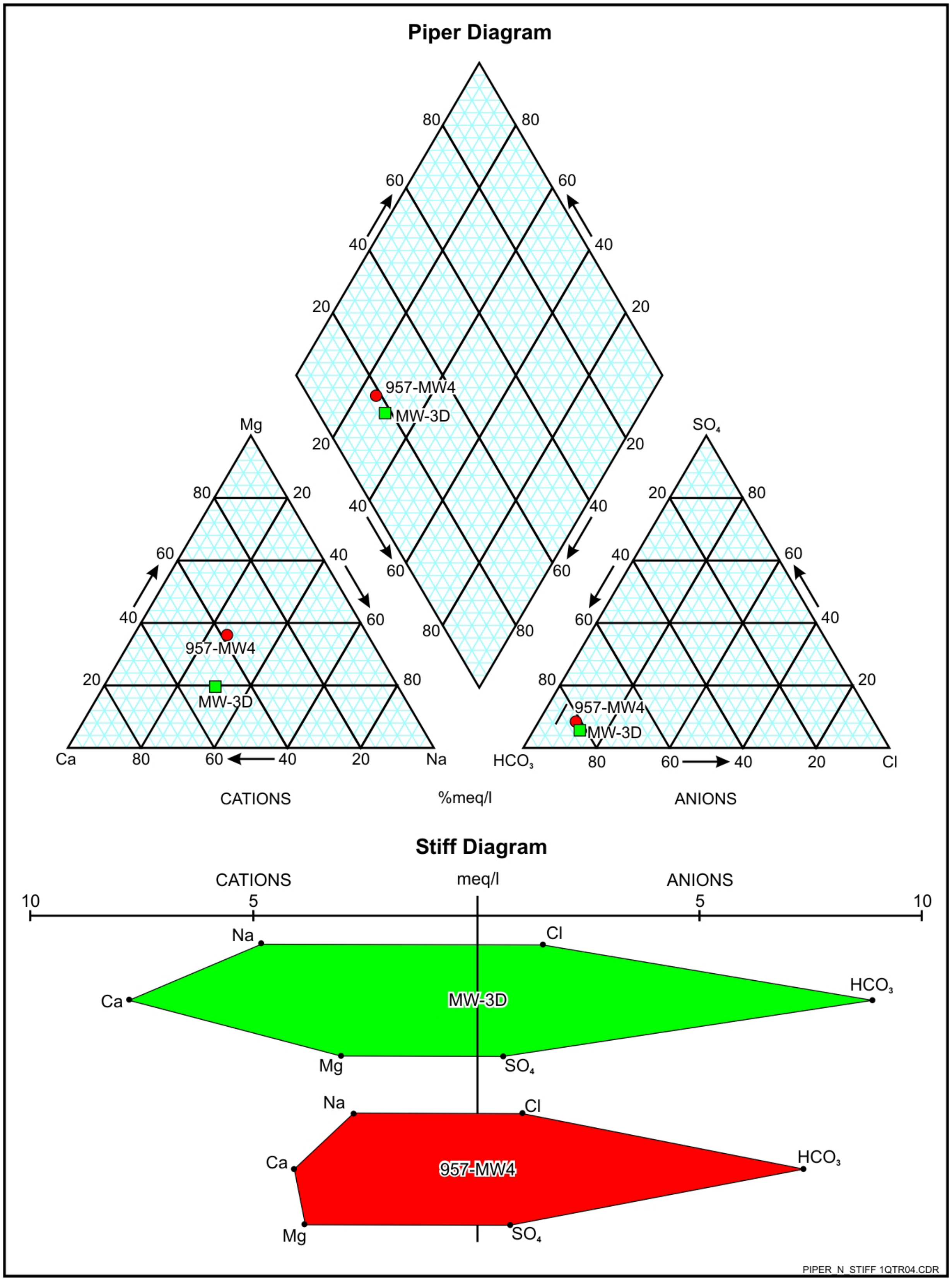


Figure 3. Piper and Stiff Diagrams for Wells MW-3D and 957-MW4

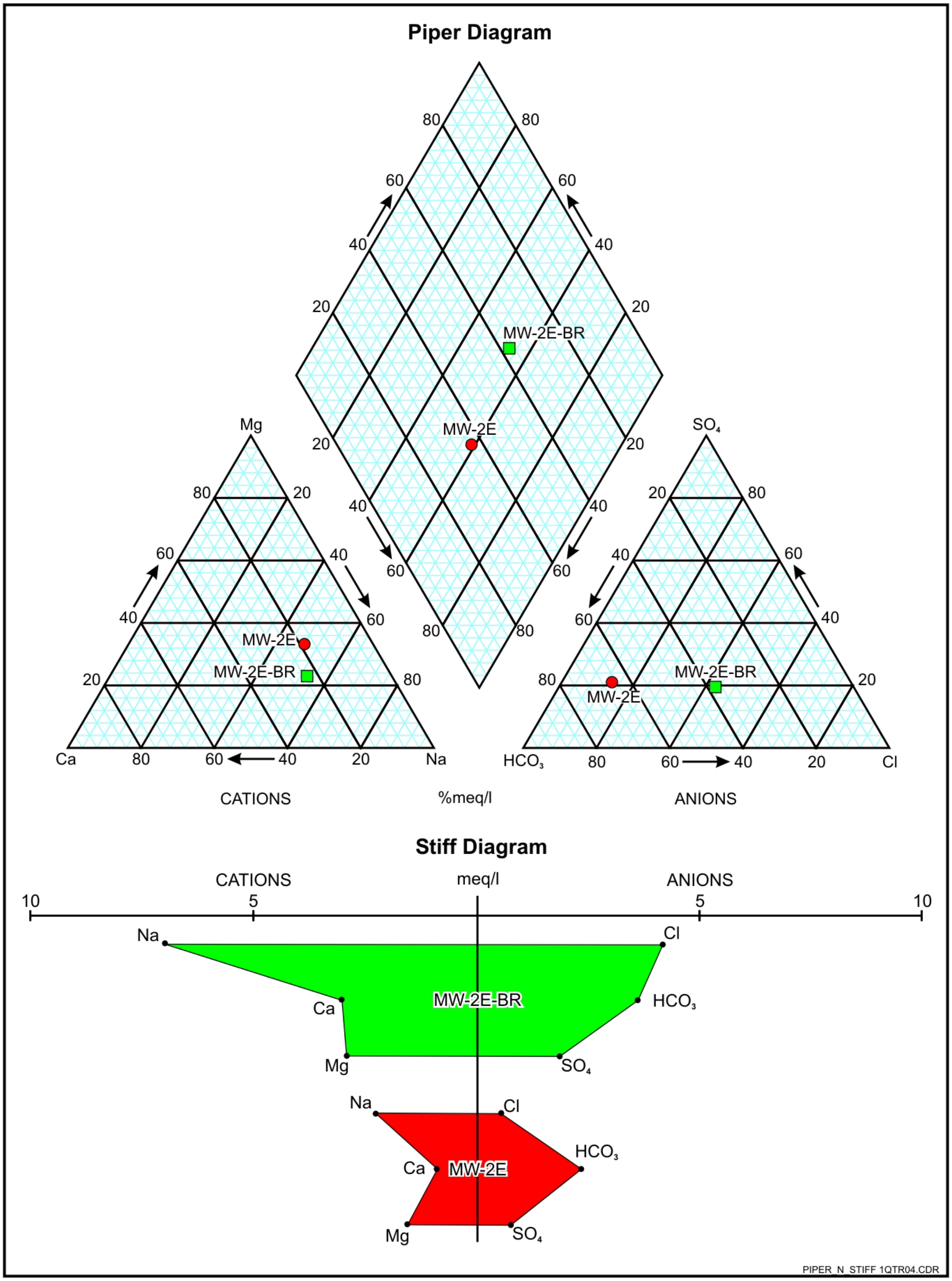


Figure 4. Piper and Stiff Diagrams for Wells MW-2E-BR and MW-2E

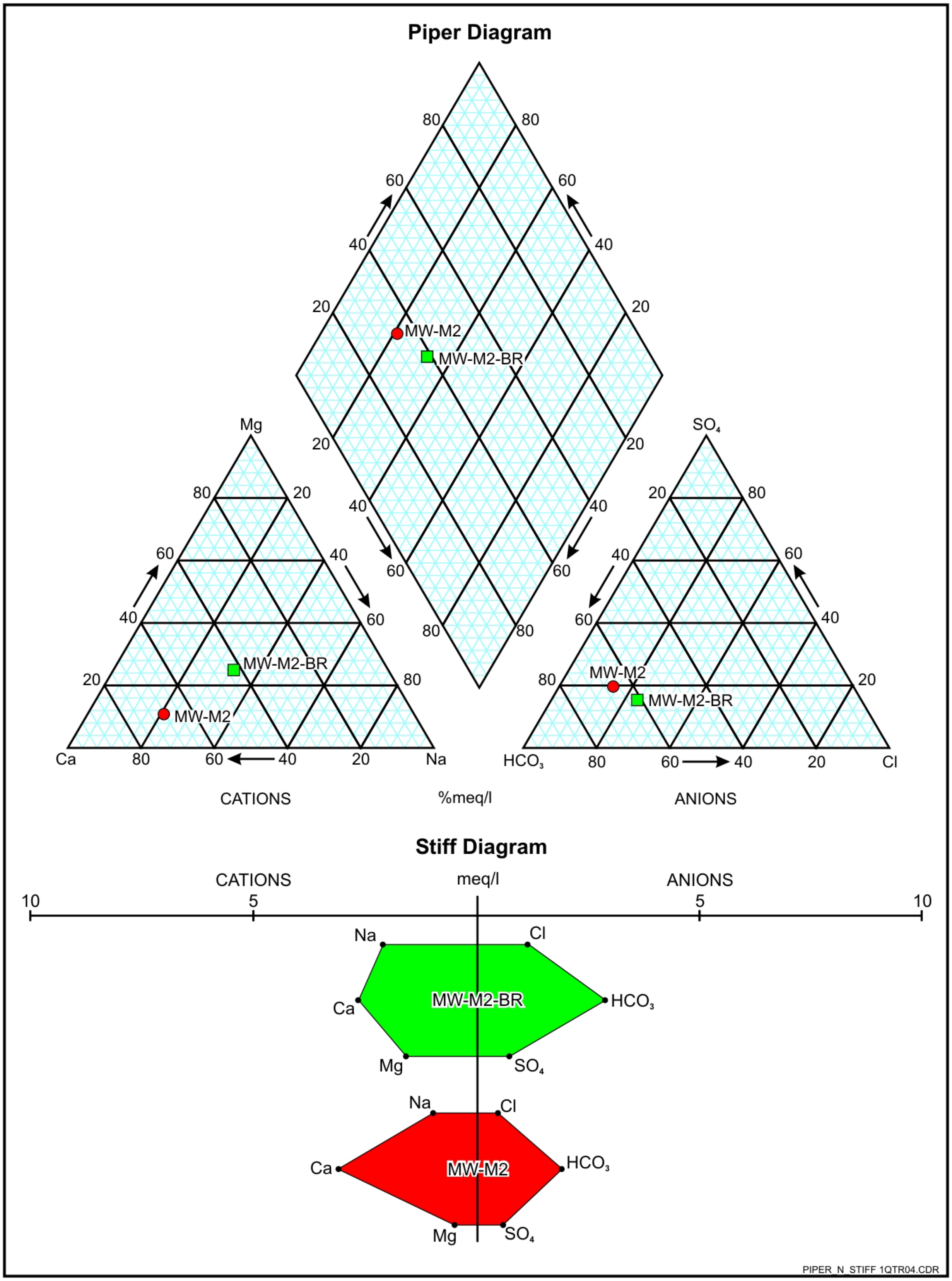


Figure 5. Piper and Stiff Diagrams for Wells MW-M2-BR and MW-M2

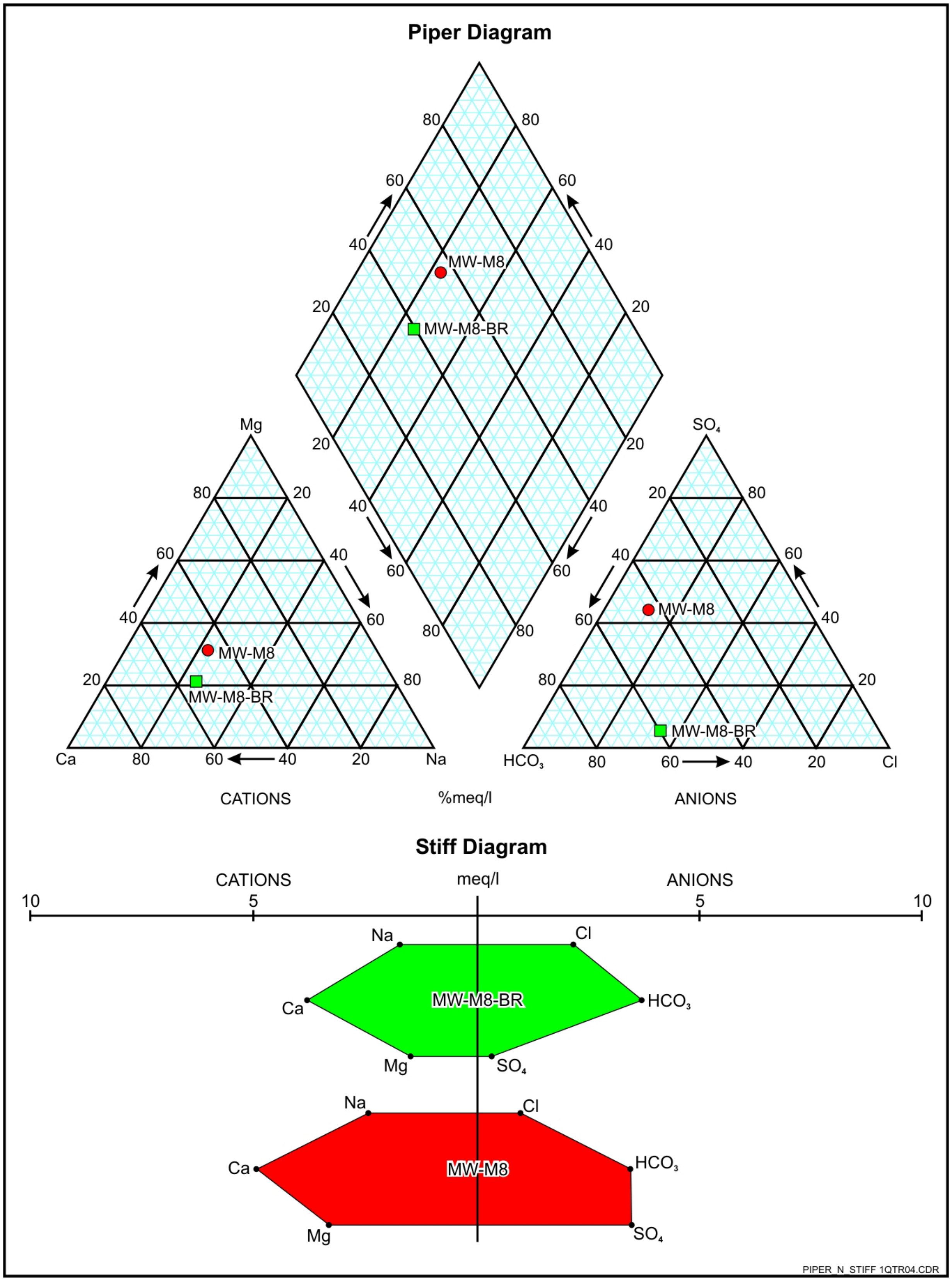


Figure 6. Piper and Stiff Diagrams for Wells MW-M8-BR and MW-M8

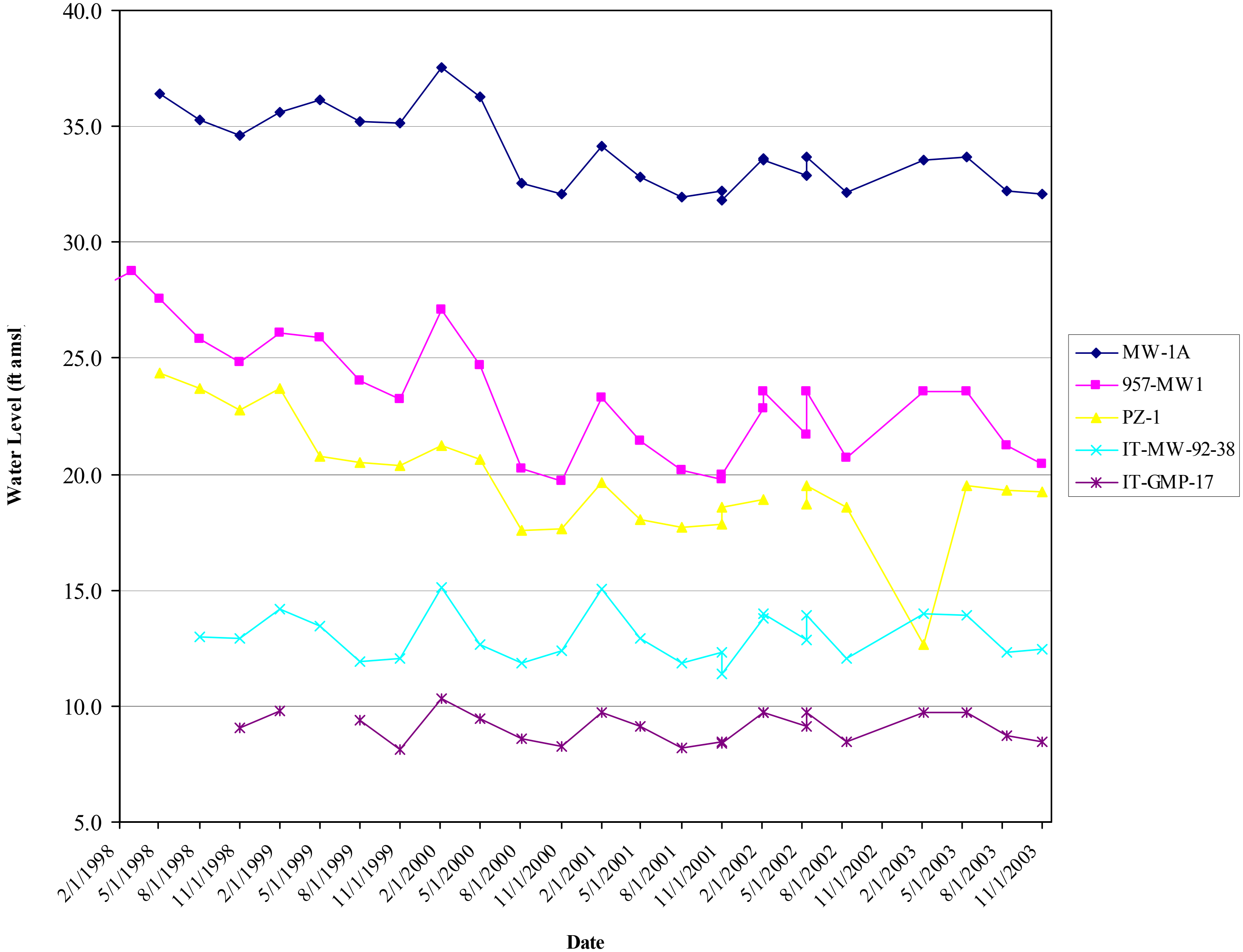


Figure 7. Water Levels Over Time at Wells Along the Plume Centerline

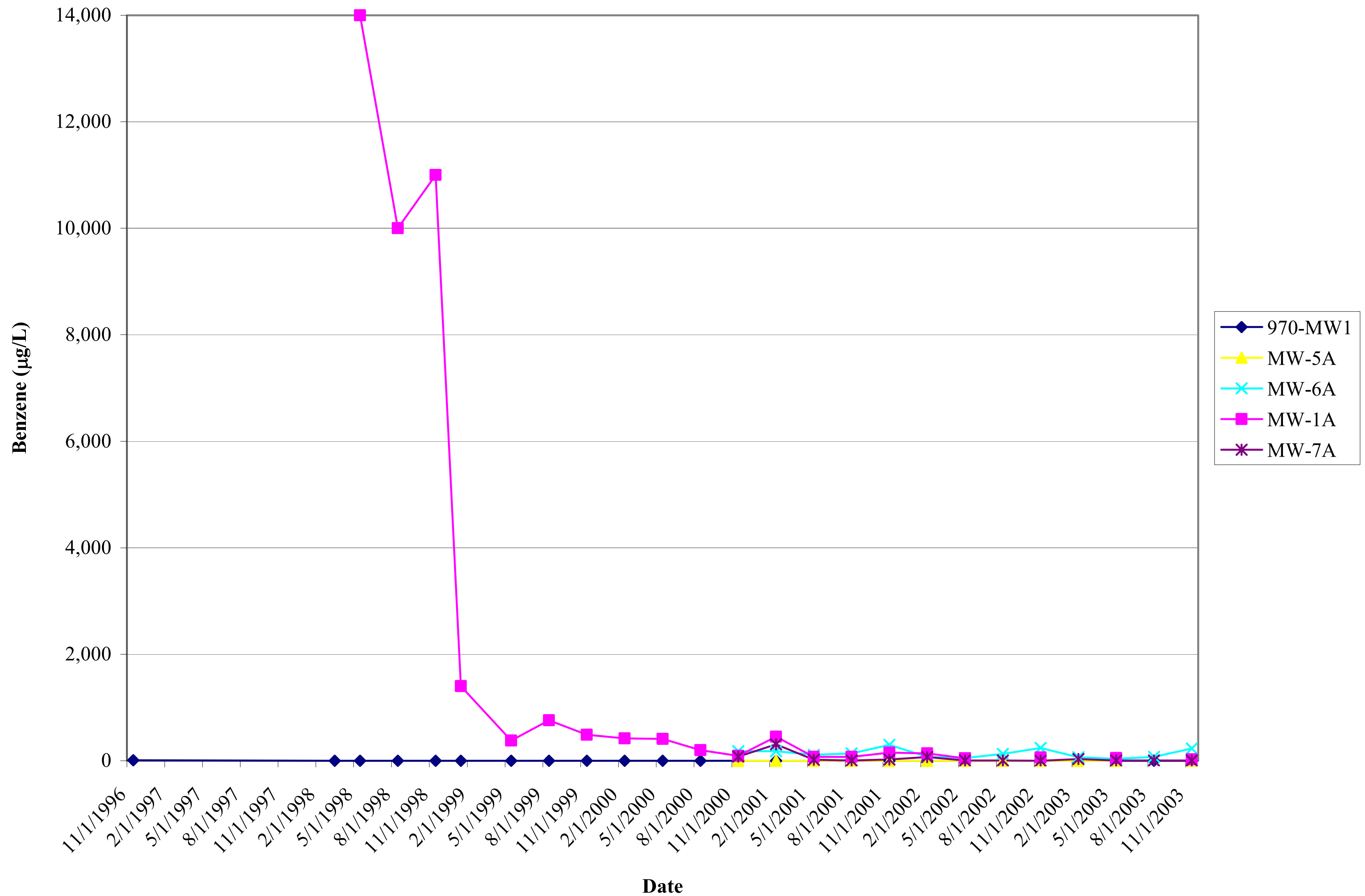


Figure 8. Area A (970 Source Area) Transect Wells Benzene Time Series Graph

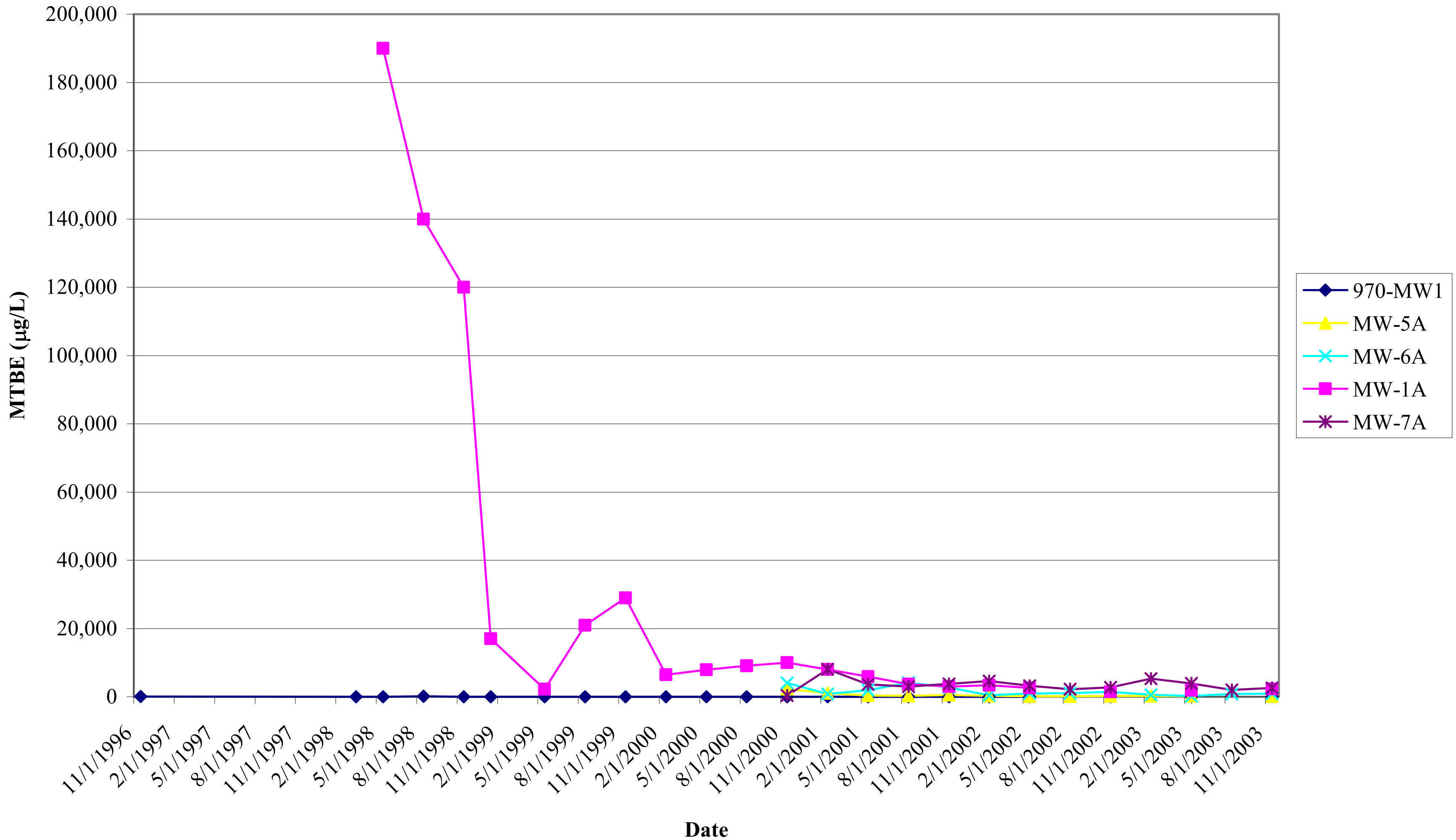


Figure 9. Area A (970 Source Area) Transect Wells MTBE Time Series Graph

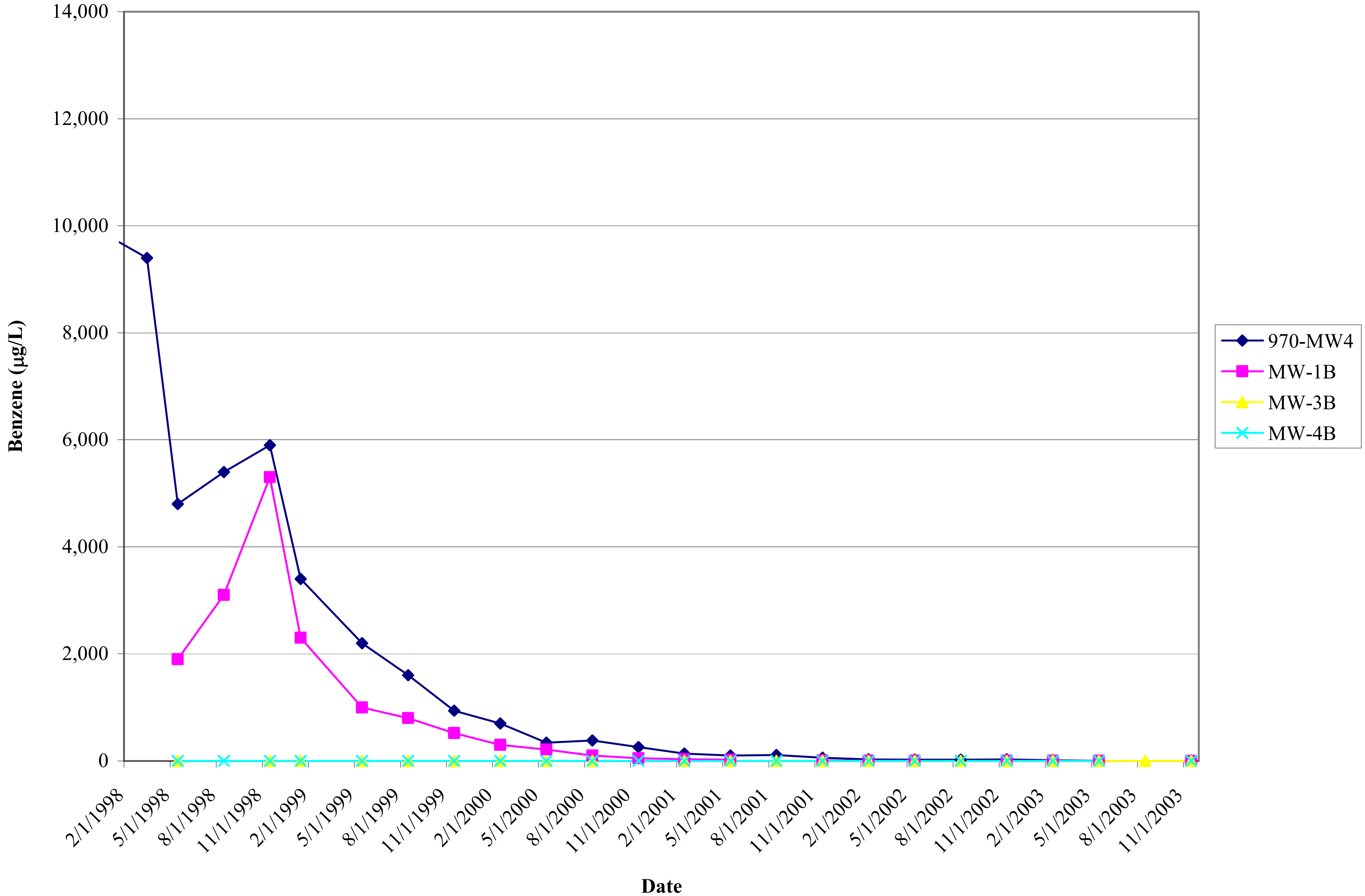


Figure 10. Area B Transect Wells Benzene Time Series Graph

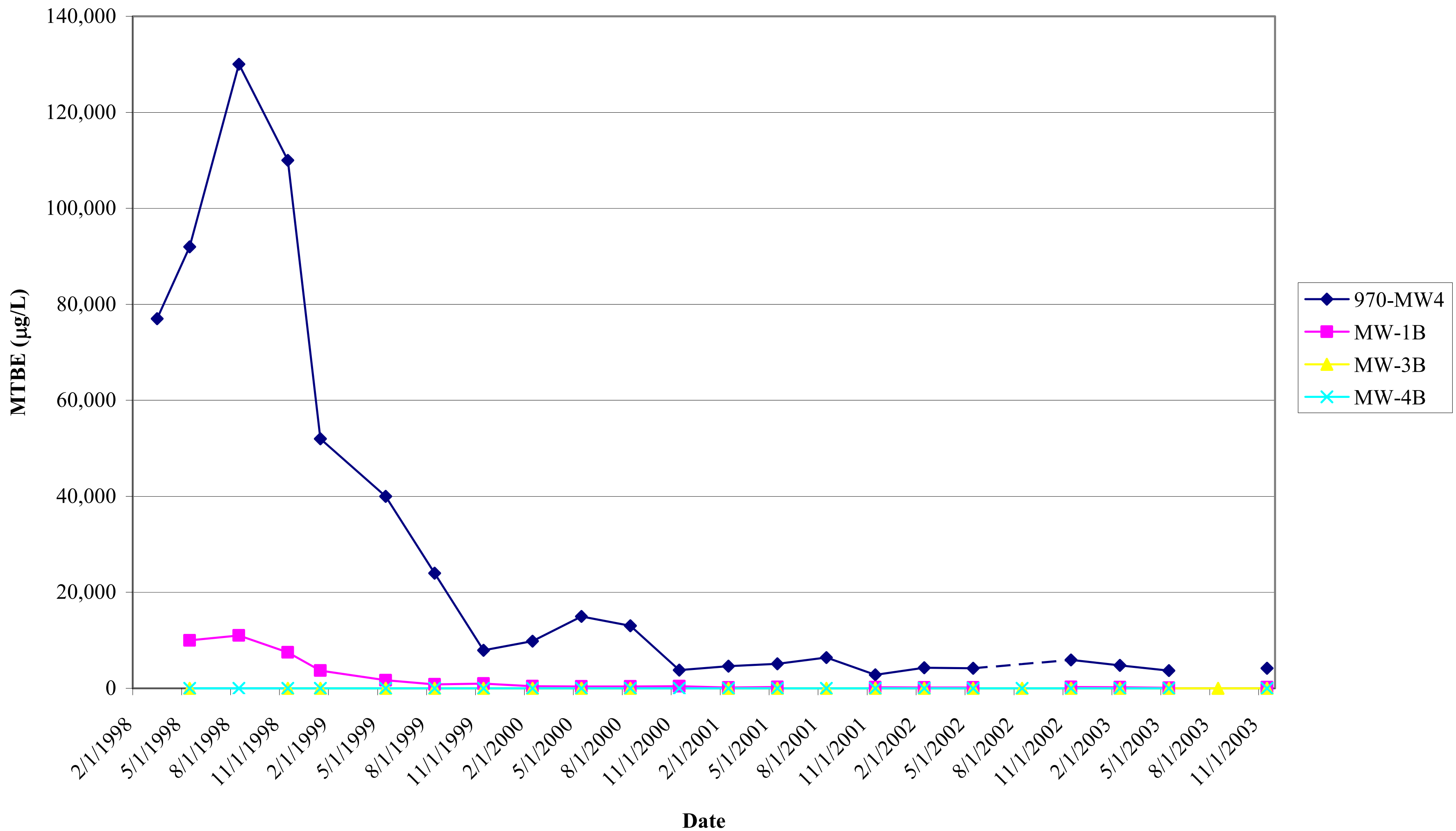


Figure 11. Area B Transect Wells MTBE Time Series Graph

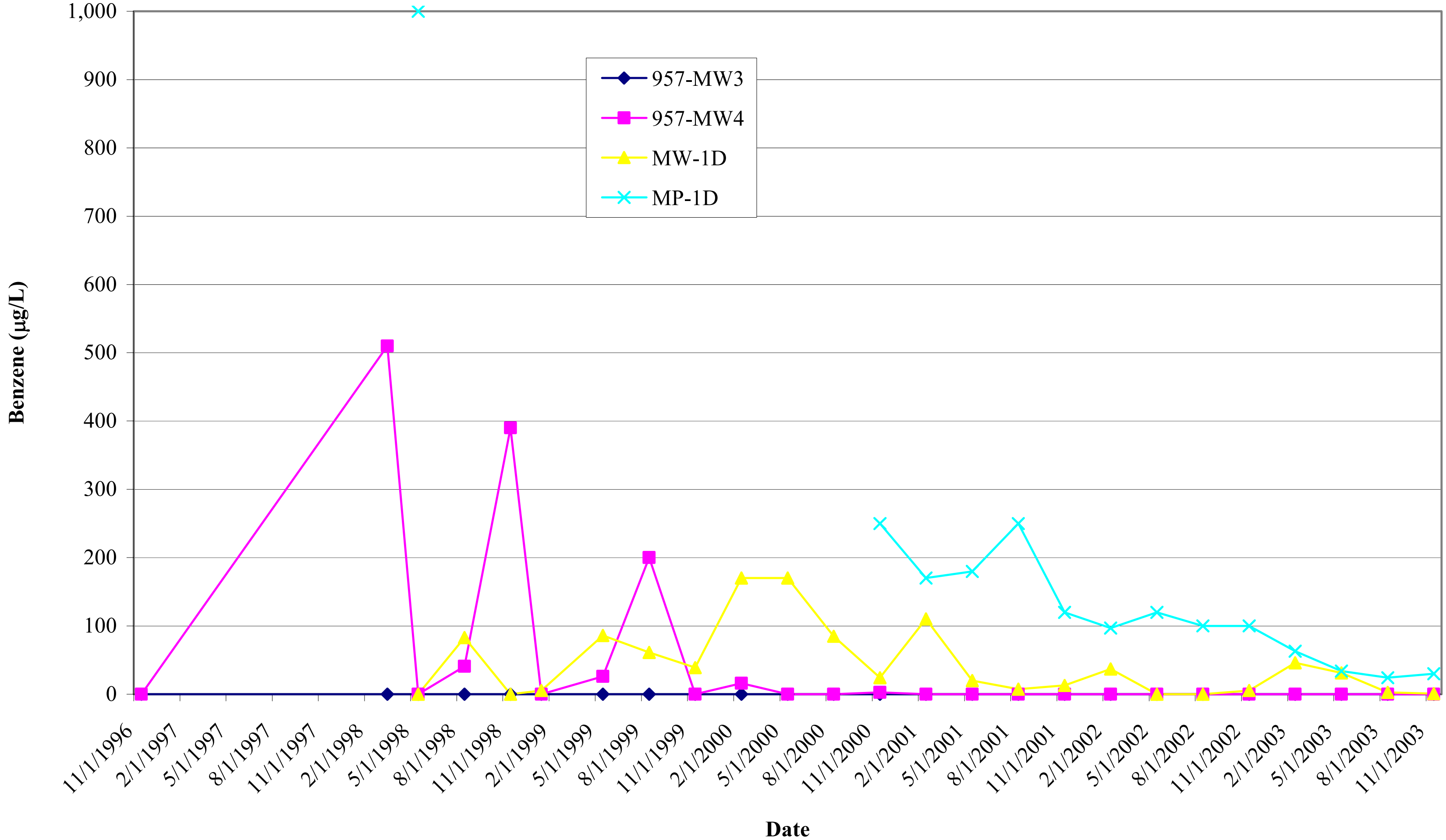


Figure 12. Area D (957 Source Area) Transect Wells Benzene Time Series Graph

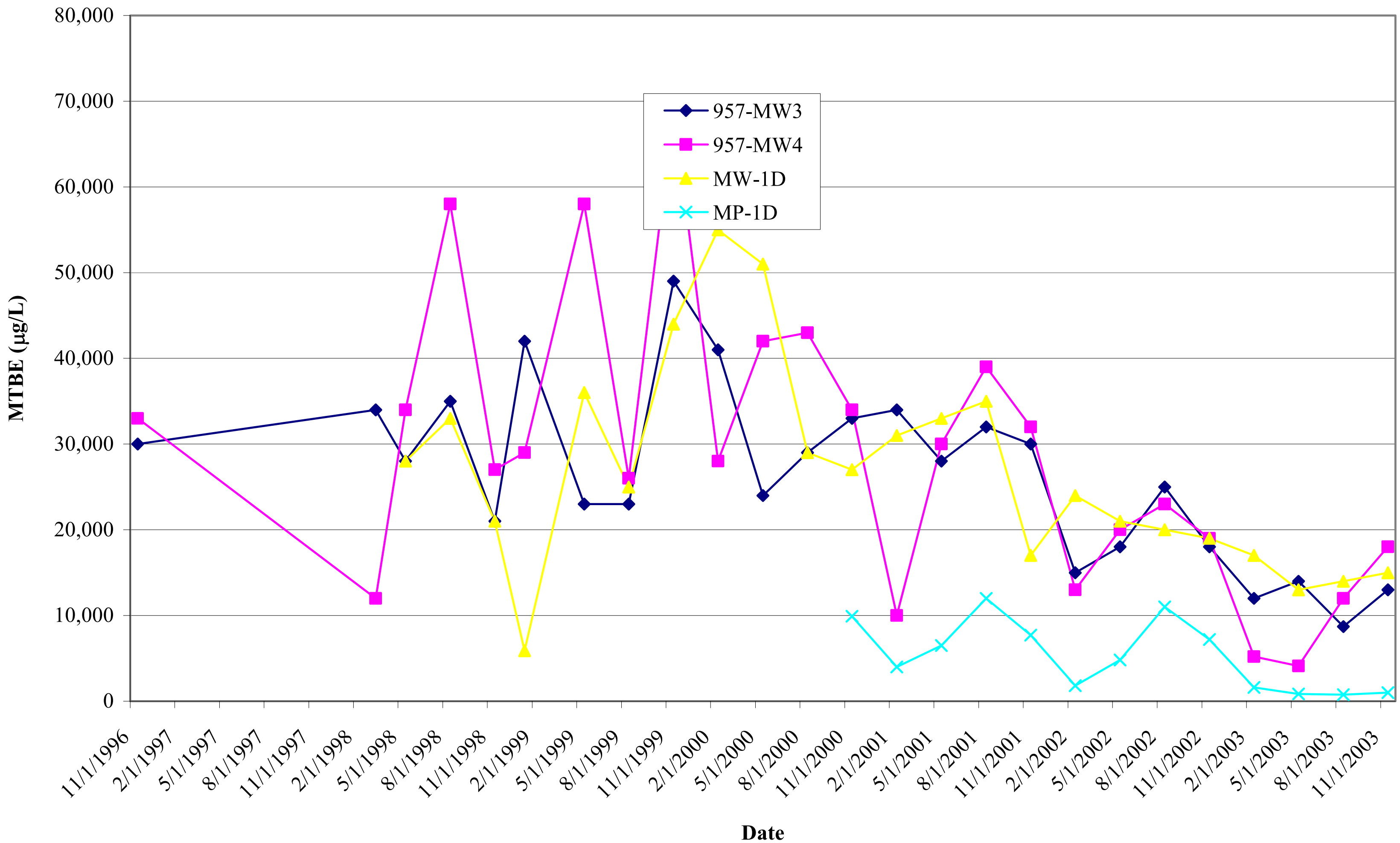


Figure 13. Area D (957 Source Area) Transect Wells MTBE Time Series Graph

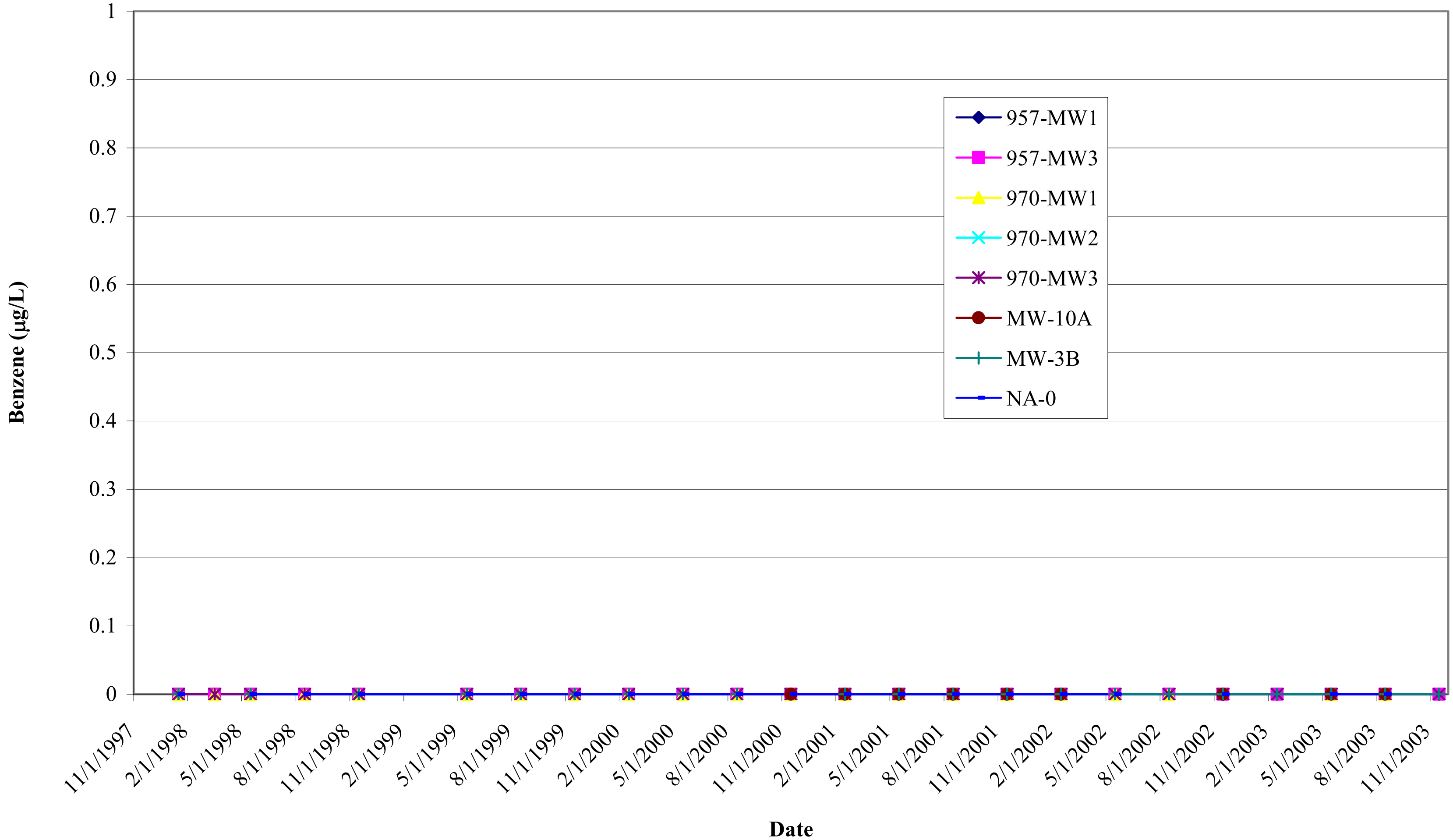


Figure 14. Plume Perimeter Wells Benzene Time Series Graph

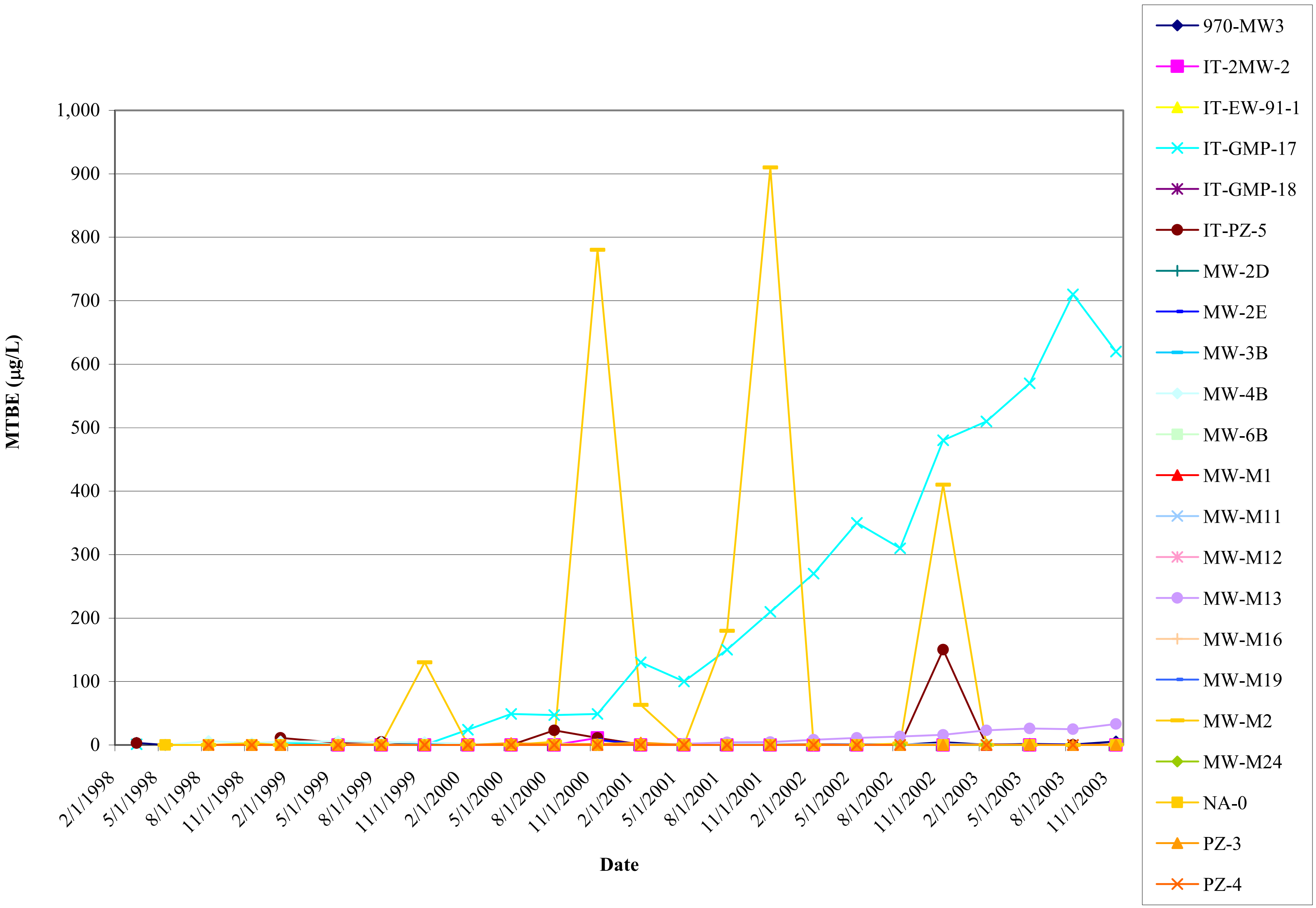


Figure 15. Plume Perimeter Wells MTBE Time Series Graph

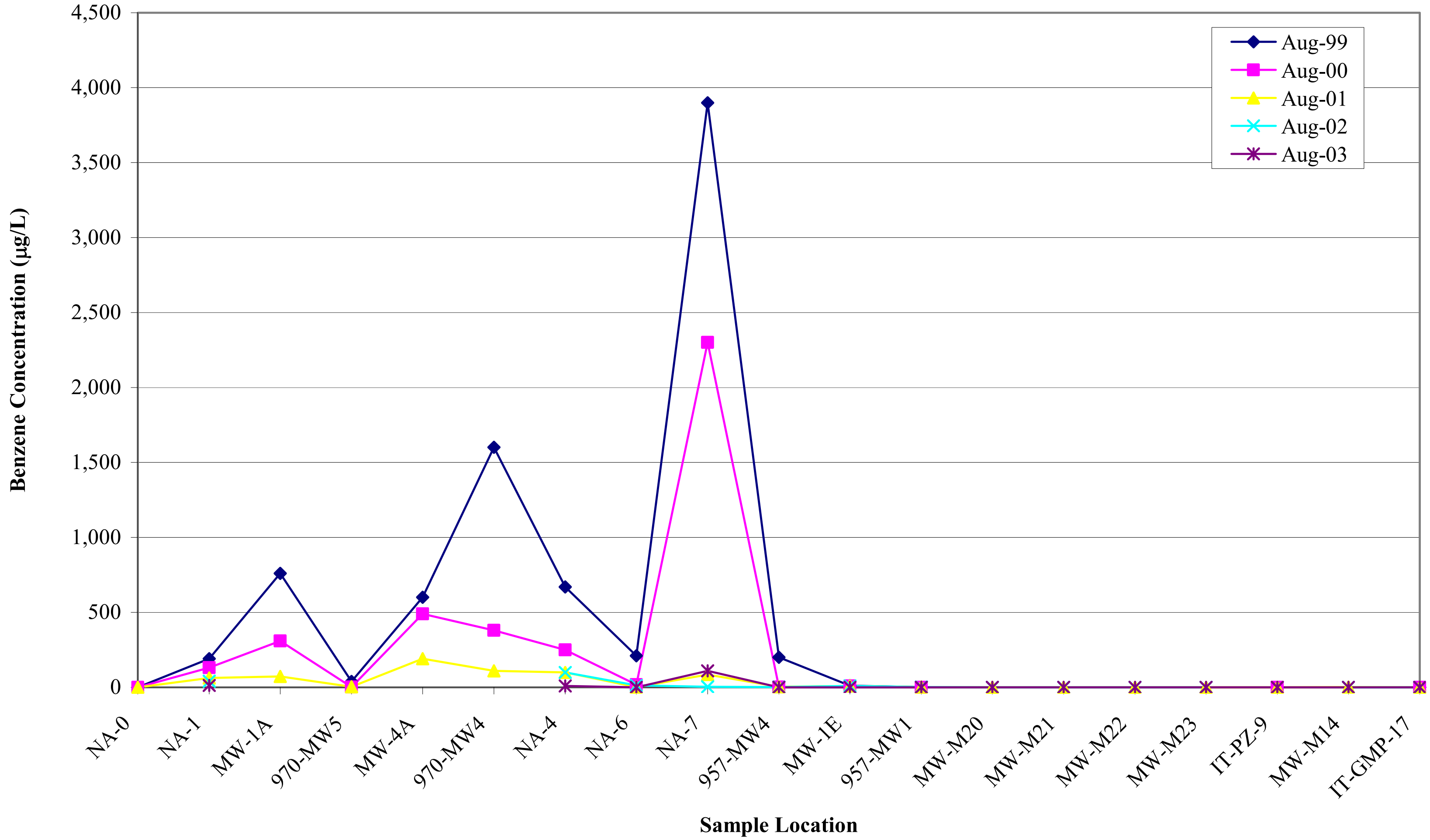


Figure 16. Centerline of Benzene Plume Annual Trends – August

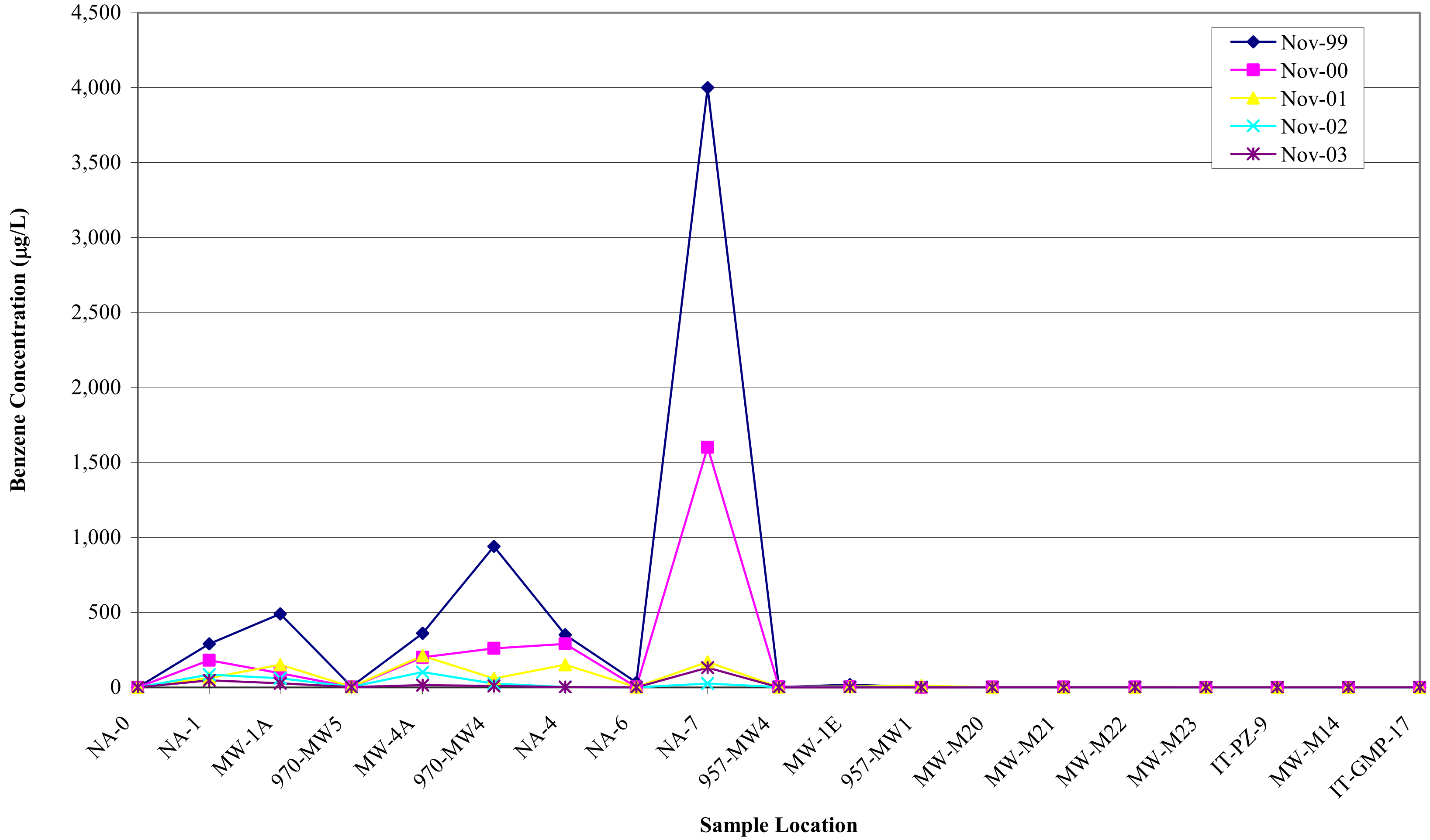


Figure 17. Centerline of Benzene Plume Annual Trends – November

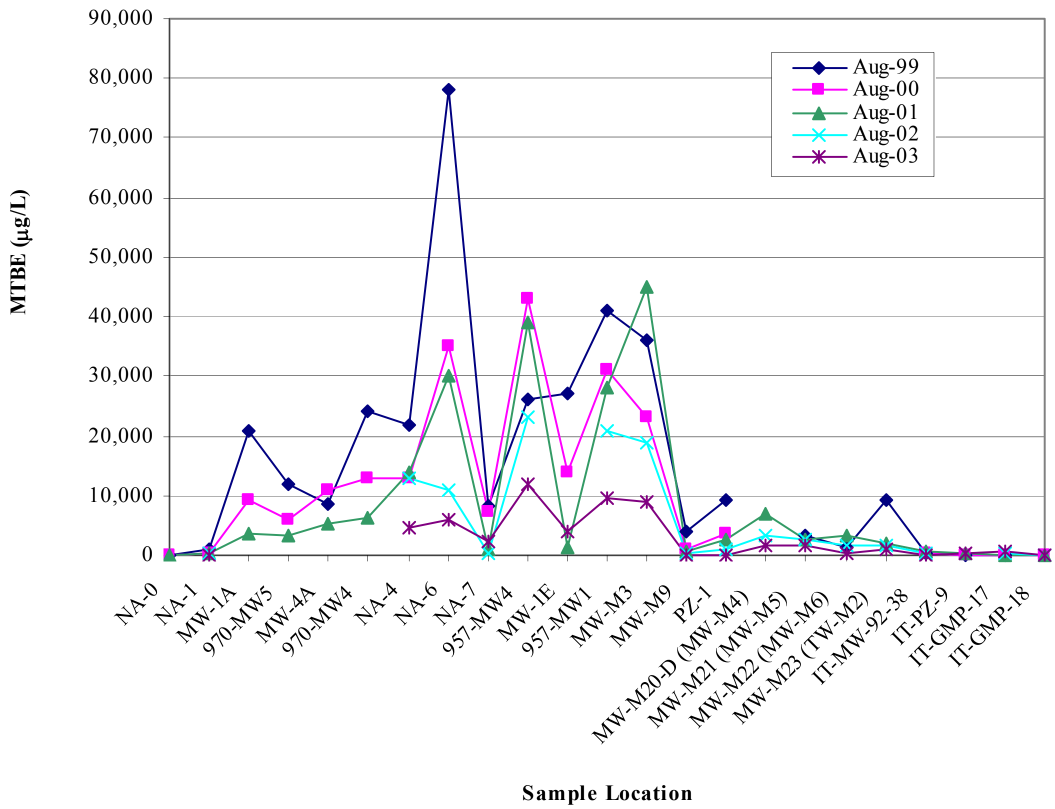


Figure 18A. Centerline of MTBE Plume Annual Trends – August

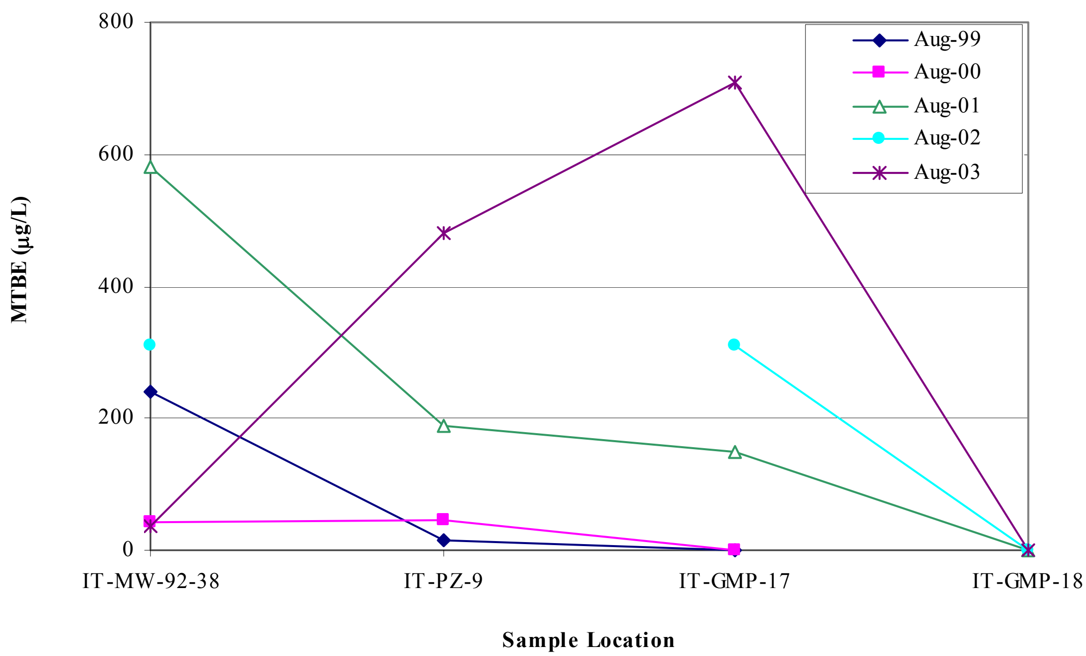


Figure 18B. Centerline of MTBE Plume (Northeast Leading Edge) Annual Trends – August

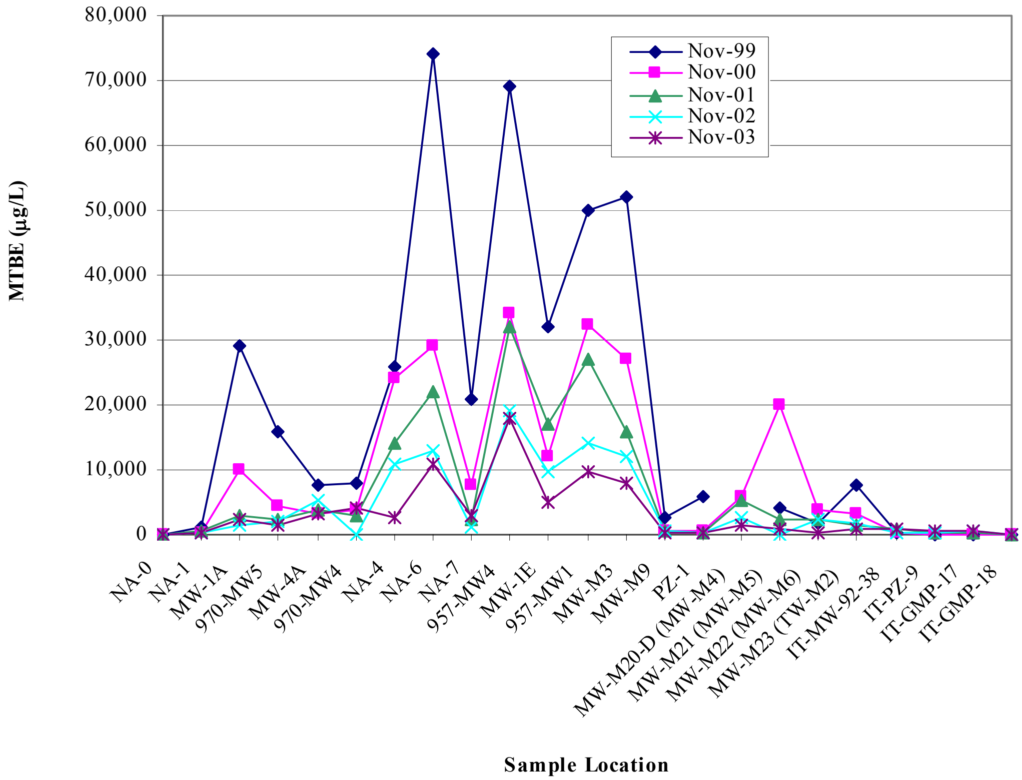


Figure 19A. Centerline of MTBE Plume Annual Trends – November

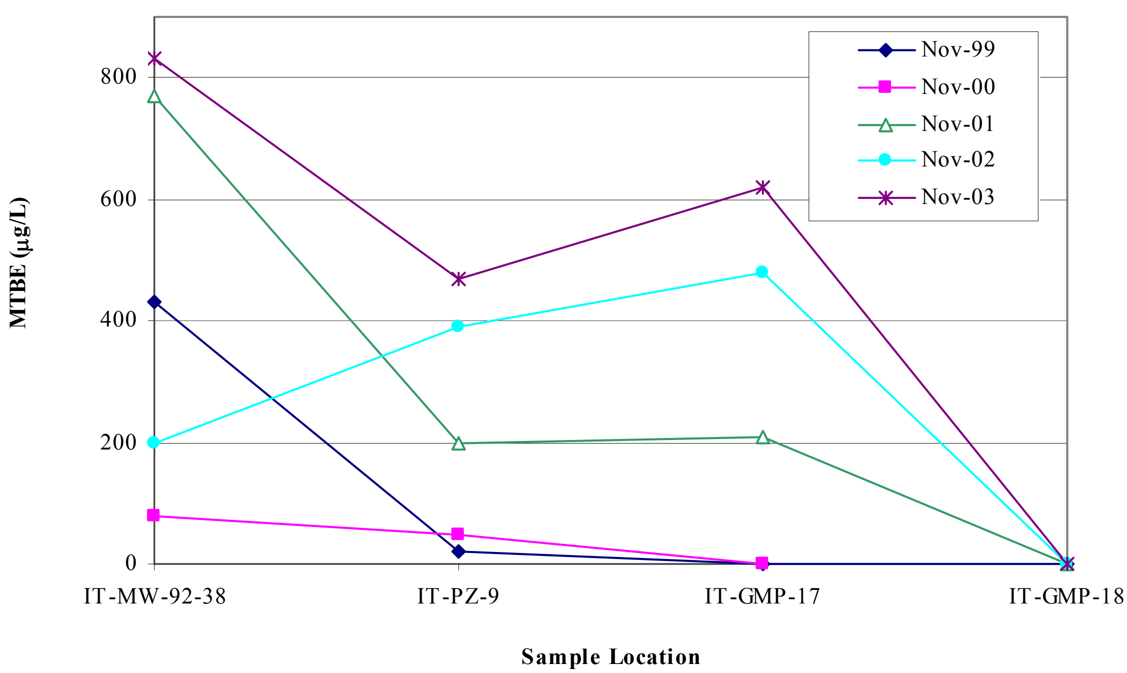
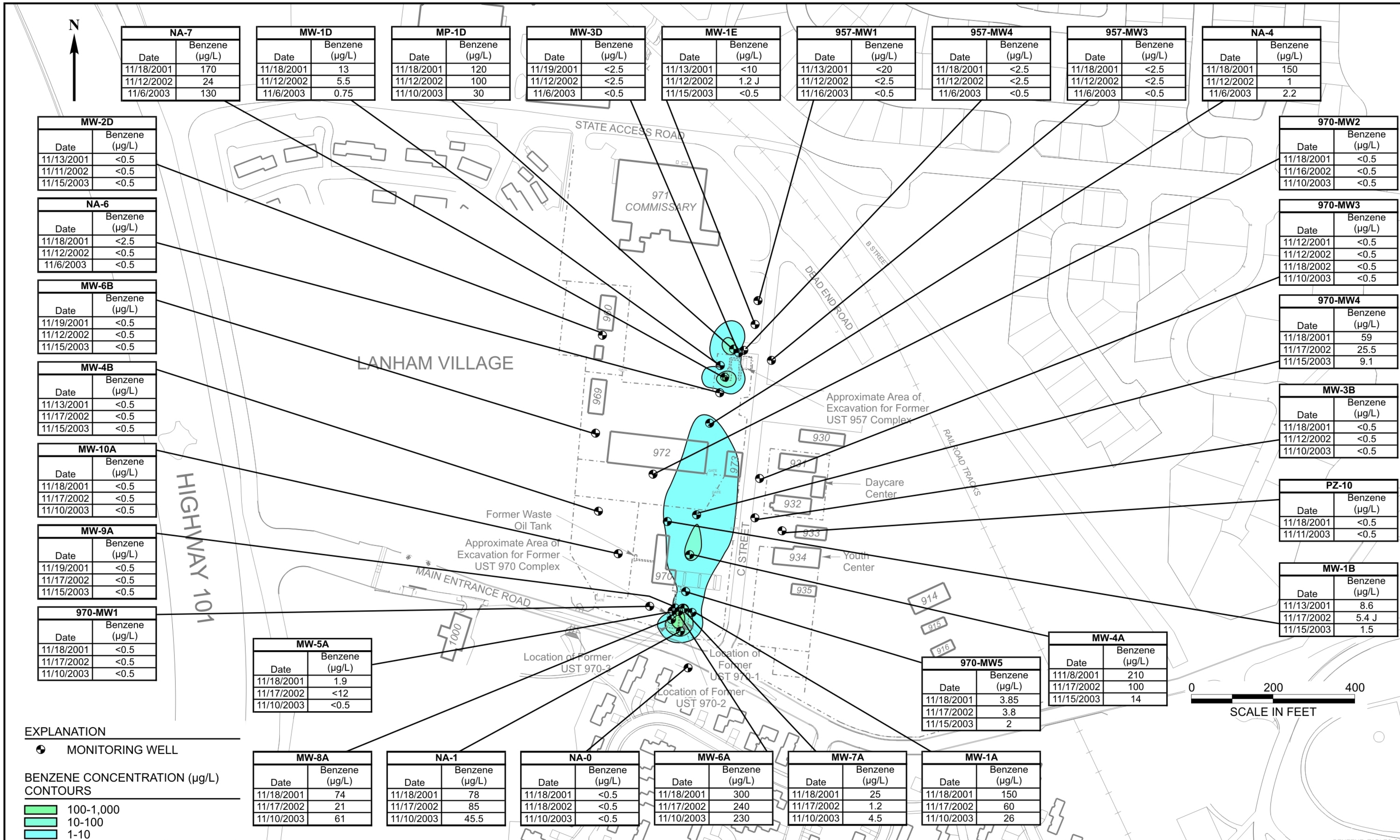


Figure 19B. Centerline of MTBE Plume (Northeast Leading Edge) Annual Trends – November



NA-7

Date	Benzene (µg/L)
11/18/2001	170
11/12/2002	24
11/6/2003	130

MW-1D

Date	Benzene (µg/L)
11/18/2001	13
11/12/2002	5.5
11/6/2003	0.75

MP-1D

Date	Benzene (µg/L)
11/18/2001	120
11/12/2002	100
11/10/2003	30

MW-3D

Date	Benzene (µg/L)
11/19/2001	<2.5
11/12/2002	<2.5
11/6/2003	<0.5

MW-1E

Date	Benzene (µg/L)
11/13/2001	<10
11/12/2002	1.2 J
11/15/2003	<0.5

957-MW1

Date	Benzene (µg/L)
11/13/2001	<20
11/12/2002	<2.5
11/16/2003	<0.5

957-MW4

Date	Benzene (µg/L)
11/18/2001	<2.5
11/12/2002	<2.5
11/6/2003	<0.5

957-MW3

Date	Benzene (µg/L)
11/18/2001	<2.5
11/12/2002	<2.5
11/6/2003	<0.5

NA-4

Date	Benzene (µg/L)
11/18/2001	150
11/12/2002	1
11/6/2003	2.2

MW-2D

Date	Benzene (µg/L)
11/13/2001	<0.5
11/11/2002	<0.5
11/15/2003	<0.5

NA-6

Date	Benzene (µg/L)
11/18/2001	<2.5
11/12/2002	<0.5
11/6/2003	<0.5

MW-6B

Date	Benzene (µg/L)
11/19/2001	<0.5
11/12/2002	<0.5
11/15/2003	<0.5

MW-4B

Date	Benzene (µg/L)
11/13/2001	<0.5
11/17/2002	<0.5
11/15/2003	<0.5

MW-10A

Date	Benzene (µg/L)
11/18/2001	<0.5
11/17/2002	<0.5
11/10/2003	<0.5

MW-9A

Date	Benzene (µg/L)
11/19/2001	<0.5
11/17/2002	<0.5
11/15/2003	<0.5

970-MW1

Date	Benzene (µg/L)
11/18/2001	<0.5
11/17/2002	<0.5
11/10/2003	<0.5

MW-5A

Date	Benzene (µg/L)
11/18/2001	1.9
11/17/2002	<12
11/10/2003	<0.5

MW-8A

Date	Benzene (µg/L)
11/18/2001	74
11/17/2002	21
11/10/2003	61

NA-1

Date	Benzene (µg/L)
11/18/2001	78
11/17/2002	85
11/10/2003	45.5

NA-0

Date	Benzene (µg/L)
11/18/2001	<0.5
11/18/2002	<0.5
11/10/2003	<0.5

MW-6A

Date	Benzene (µg/L)
11/18/2001	300
11/17/2002	240
11/10/2003	230

MW-7A

Date	Benzene (µg/L)
11/18/2001	25
11/17/2002	1.2
11/10/2003	4.5

MW-1A

Date	Benzene (µg/L)
11/18/2001	150
11/17/2002	60
11/10/2003	26

970-MW5

Date	Benzene (µg/L)
11/18/2001	3.85
11/17/2002	3.8
11/15/2003	2

MW-4A

Date	Benzene (µg/L)
111/8/2001	210
11/17/2002	100
11/15/2003	14

970-MW2

Date	Benzene (µg/L)
11/18/2001	<0.5
11/16/2002	<0.5
11/10/2003	<0.5

970-MW3

Date	Benzene (µg/L)
11/12/2001	<0.5
11/12/2002	<0.5
11/18/2002	<0.5
11/10/2003	<0.5

970-MW4

Date	Benzene (µg/L)
11/18/2001	59
11/17/2002	25.5
11/15/2003	9.1

MW-3B

Date	Benzene (µg/L)
11/18/2001	<0.5
11/12/2002	<0.5
11/10/2003	<0.5

PZ-10

Date	Benzene (µg/L)
11/18/2001	<0.5
11/11/2003	<0.5

MW-1B

Date	Benzene (µg/L)
11/13/2001	8.6
11/17/2002	5.4 J
11/15/2003	1.5

Figure 20. Benzene Plume Contours (November 2003) and Historical Benzene Data

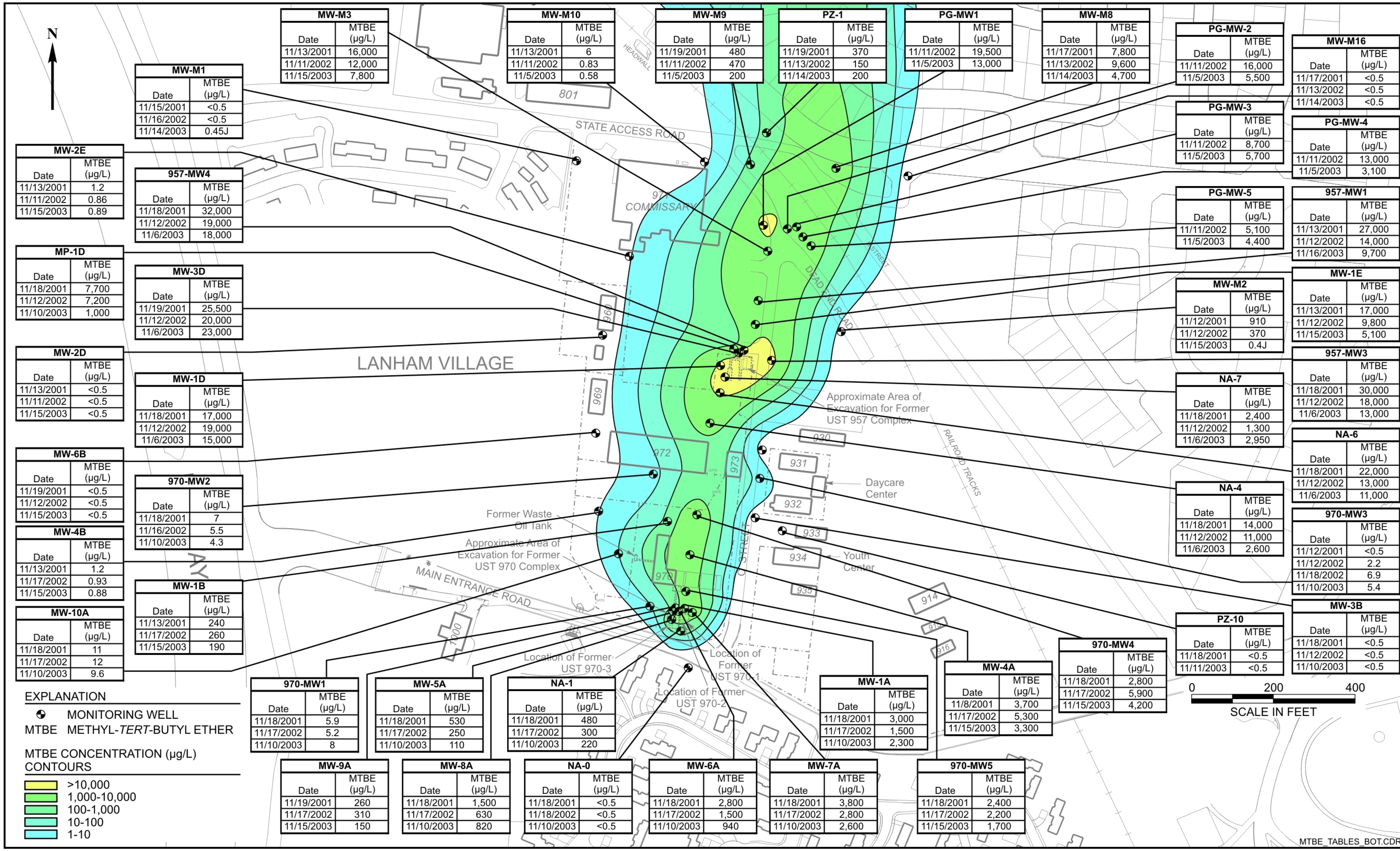
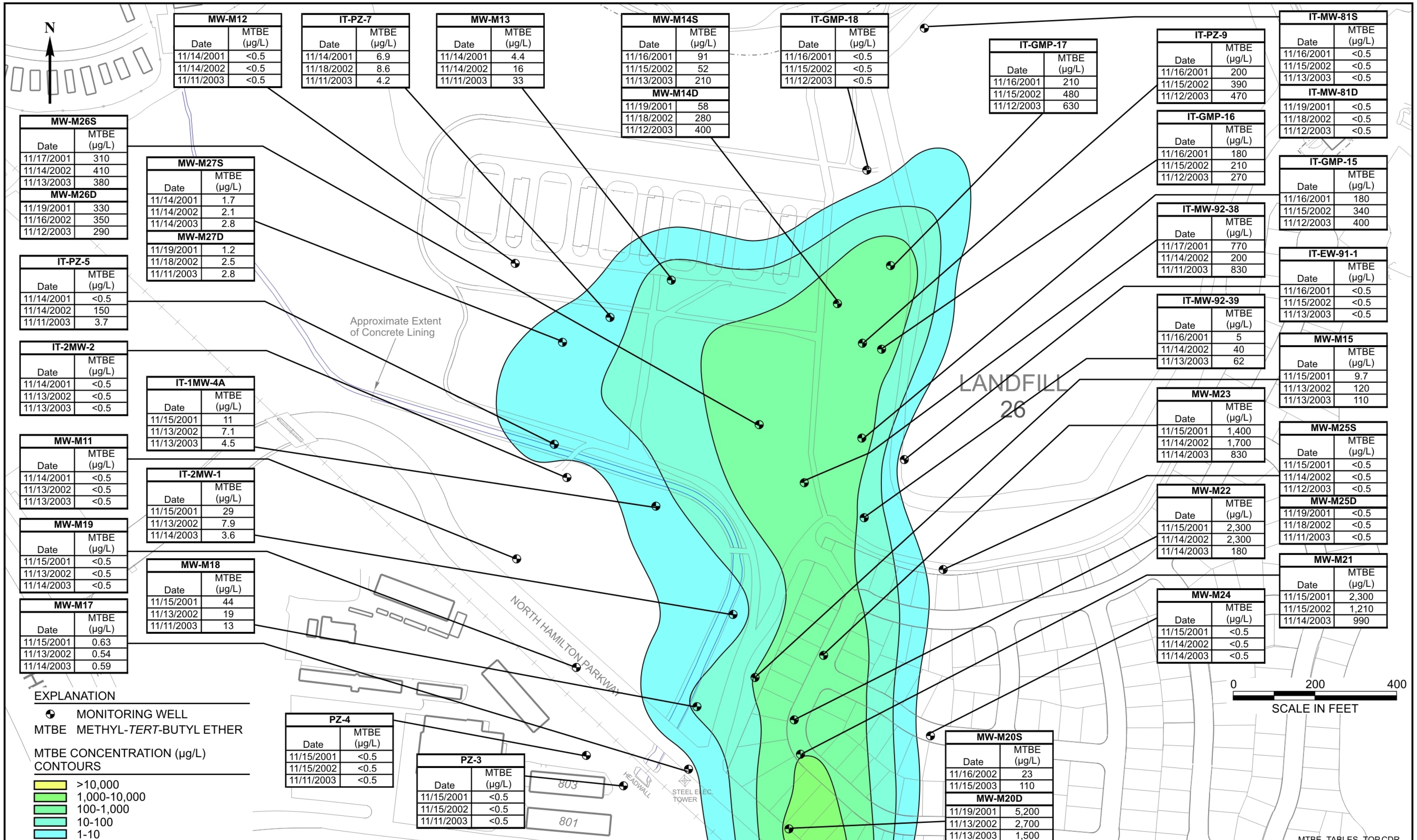


Figure 21. MTBE Plume Contours (November 2003) and Historical MTBE Data



MW-M12 Date	MTBE (µg/L)
11/14/2001	<0.5
11/14/2002	<0.5
11/11/2003	<0.5

IT-PZ-7 Date	MTBE (µg/L)
11/14/2001	6.9
11/18/2002	8.6
11/11/2003	4.2

MW-M13 Date	MTBE (µg/L)
11/14/2001	4.4
11/14/2002	16
11/11/2003	33

MW-M14S Date	MTBE (µg/L)
11/16/2001	91
11/15/2002	52
11/13/2003	210
MW-M14D	
11/19/2001	58
11/18/2002	280
11/12/2003	400

IT-GMP-18 Date	MTBE (µg/L)
11/16/2001	<0.5
11/15/2002	<0.5
11/12/2003	<0.5

IT-GMP-17 Date	MTBE (µg/L)
11/16/2001	210
11/15/2002	480
11/12/2003	630

IT-PZ-9 Date	MTBE (µg/L)
11/16/2001	200
11/15/2002	390
11/12/2003	470

IT-MW-81S Date	MTBE (µg/L)
11/16/2001	<0.5
11/15/2002	<0.5
11/13/2003	<0.5
IT-MW-81D	
11/19/2001	<0.5
11/18/2002	<0.5
11/12/2003	<0.5

MW-M26S Date	MTBE (µg/L)
11/17/2001	310
11/14/2002	410
11/13/2003	380
MW-M26D	
11/19/2001	330
11/16/2002	350
11/12/2003	290

MW-M27S Date	MTBE (µg/L)
11/14/2001	1.7
11/14/2002	2.1
11/14/2003	2.8
MW-M27D	
11/19/2001	1.2
11/18/2002	2.5
11/11/2003	2.8

IT-GMP-16 Date	MTBE (µg/L)
11/16/2001	180
11/15/2002	210
11/12/2003	270

IT-GMP-15 Date	MTBE (µg/L)
11/16/2001	180
11/15/2002	340
11/12/2003	400

IT-MW-92-38 Date	MTBE (µg/L)
11/17/2001	770
11/14/2002	200
11/11/2003	830

IT-EW-91-1 Date	MTBE (µg/L)
11/16/2001	<0.5
11/15/2002	<0.5
11/13/2003	<0.5

IT-PZ-5 Date	MTBE (µg/L)
11/14/2001	<0.5
11/14/2002	150
11/11/2003	3.7

IT-MW-92-39 Date	MTBE (µg/L)
11/16/2001	5
11/14/2002	40
11/13/2003	62

MW-M15 Date	MTBE (µg/L)
11/15/2001	9.7
11/13/2002	120
11/13/2003	110

IT-2MW-2 Date	MTBE (µg/L)
11/14/2001	<0.5
11/13/2002	<0.5
11/13/2003	<0.5

IT-1MW-4A Date	MTBE (µg/L)
11/15/2001	11
11/13/2002	7.1
11/13/2003	4.5

MW-M23 Date	MTBE (µg/L)
11/15/2001	1,400
11/14/2002	1,700
11/14/2003	830

MW-M25S Date	MTBE (µg/L)
11/15/2001	<0.5
11/14/2002	<0.5
11/12/2003	<0.5
MW-M25D	
11/19/2001	<0.5
11/18/2002	<0.5
11/11/2003	<0.5

MW-M11 Date	MTBE (µg/L)
11/14/2001	<0.5
11/13/2002	<0.5
11/13/2003	<0.5

IT-2MW-1 Date	MTBE (µg/L)
11/15/2001	29
11/13/2002	7.9
11/14/2003	3.6

MW-M22 Date	MTBE (µg/L)
11/15/2001	2,300
11/14/2002	2,300
11/14/2003	180

MW-M19 Date	MTBE (µg/L)
11/15/2001	<0.5
11/13/2002	<0.5
11/14/2003	<0.5

MW-M18 Date	MTBE (µg/L)
11/15/2001	44
11/13/2002	19
11/11/2003	13

MW-M21 Date	MTBE (µg/L)
11/15/2001	2,300
11/15/2002	1,210
11/14/2003	990

MW-M24 Date	MTBE (µg/L)
11/15/2001	<0.5
11/14/2002	<0.5
11/14/2003	<0.5

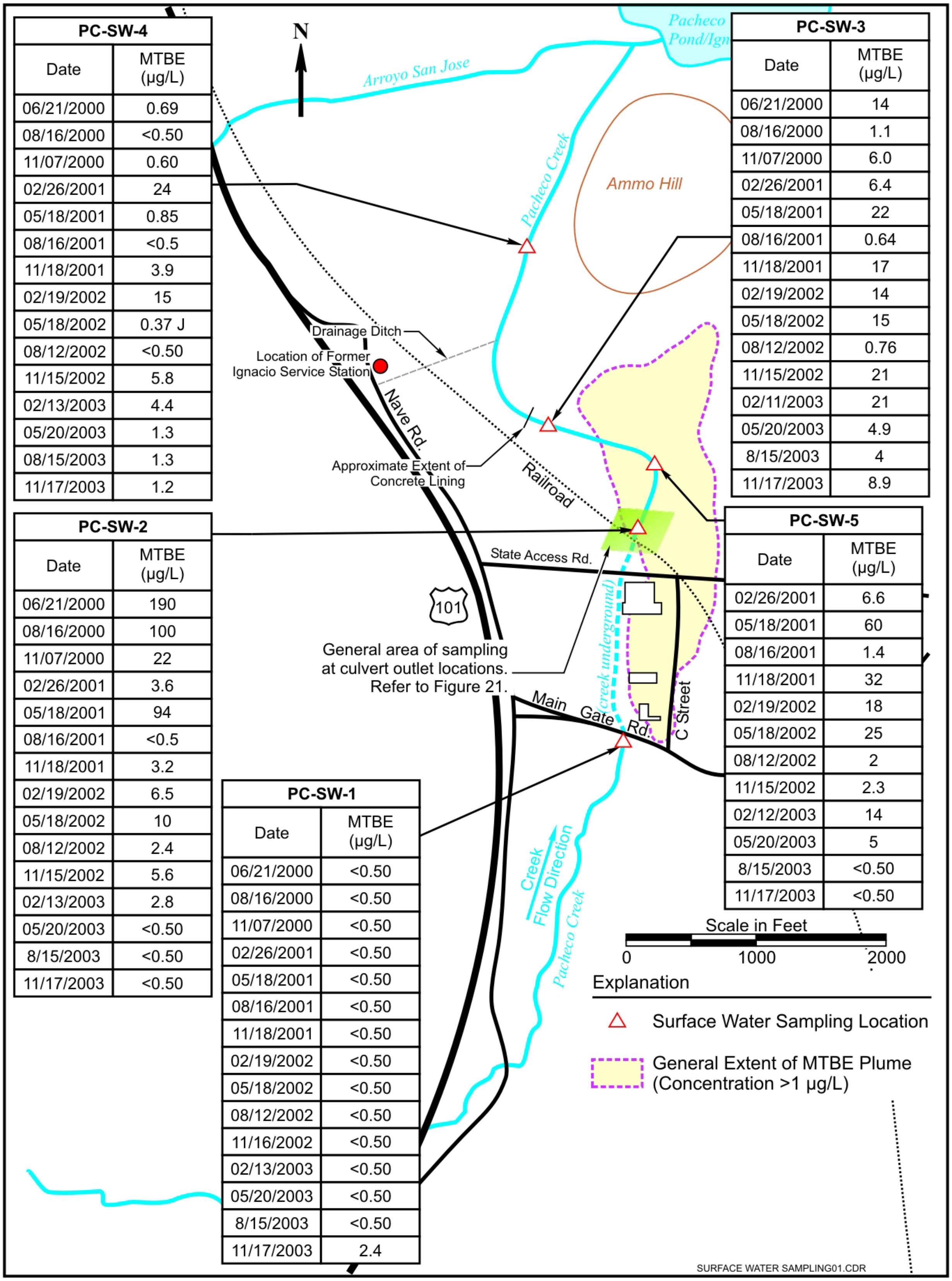
MW-M17 Date	MTBE (µg/L)
11/15/2001	0.63
11/13/2002	0.54
11/14/2003	0.59

PZ-4 Date	MTBE (µg/L)
11/15/2001	<0.5
11/15/2002	<0.5
11/11/2003	<0.5

PZ-3 Date	MTBE (µg/L)
11/15/2001	<0.5
11/15/2002	<0.5
11/11/2003	<0.5

MW-M20S Date	MTBE (µg/L)
11/16/2002	23
11/15/2003	110
MW-M20D	
11/19/2001	5,200
11/13/2002	2,700
11/13/2003	1,500

Figure 21. MTBE Plume Contours (November 2003) and Historical MTBE Data (Continued)



PC-SW-4	
Date	MTBE (µg/L)
06/21/2000	0.69
08/16/2000	<0.50
11/07/2000	0.60
02/26/2001	24
05/18/2001	0.85
08/16/2001	<0.5
11/18/2001	3.9
02/19/2002	15
05/18/2002	0.37 J
08/12/2002	<0.50
11/15/2002	5.8
02/13/2003	4.4
05/20/2003	1.3
08/15/2003	1.3
11/17/2003	1.2

PC-SW-3	
Date	MTBE (µg/L)
06/21/2000	14
08/16/2000	1.1
11/07/2000	6.0
02/26/2001	6.4
05/18/2001	22
08/16/2001	0.64
11/18/2001	17
02/19/2002	14
05/18/2002	15
08/12/2002	0.76
11/15/2002	21
02/11/2003	21
05/20/2003	4.9
8/15/2003	4
11/17/2003	8.9

PC-SW-2	
Date	MTBE (µg/L)
06/21/2000	190
08/16/2000	100
11/07/2000	22
02/26/2001	3.6
05/18/2001	94
08/16/2001	<0.5
11/18/2001	3.2
02/19/2002	6.5
05/18/2002	10
08/12/2002	2.4
11/15/2002	5.6
02/13/2003	2.8
05/20/2003	<0.50
8/15/2003	<0.50
11/17/2003	<0.50

PC-SW-5	
Date	MTBE (µg/L)
02/26/2001	6.6
05/18/2001	60
08/16/2001	1.4
11/18/2001	32
02/19/2002	18
05/18/2002	25
08/12/2002	2
11/15/2002	2.3
02/12/2003	14
05/20/2003	5
8/15/2003	<0.50
11/17/2003	<0.50

PC-SW-1	
Date	MTBE (µg/L)
06/21/2000	<0.50
08/16/2000	<0.50
11/07/2000	<0.50
02/26/2001	<0.50
05/18/2001	<0.50
08/16/2001	<0.50
11/18/2001	<0.50
02/19/2002	<0.50
05/18/2002	<0.50
08/12/2002	<0.50
11/16/2002	<0.50
02/13/2003	<0.50
05/20/2003	<0.50
8/15/2003	<0.50
11/17/2003	2.4

Figure 22. MTBE Concentrations in Surface Water

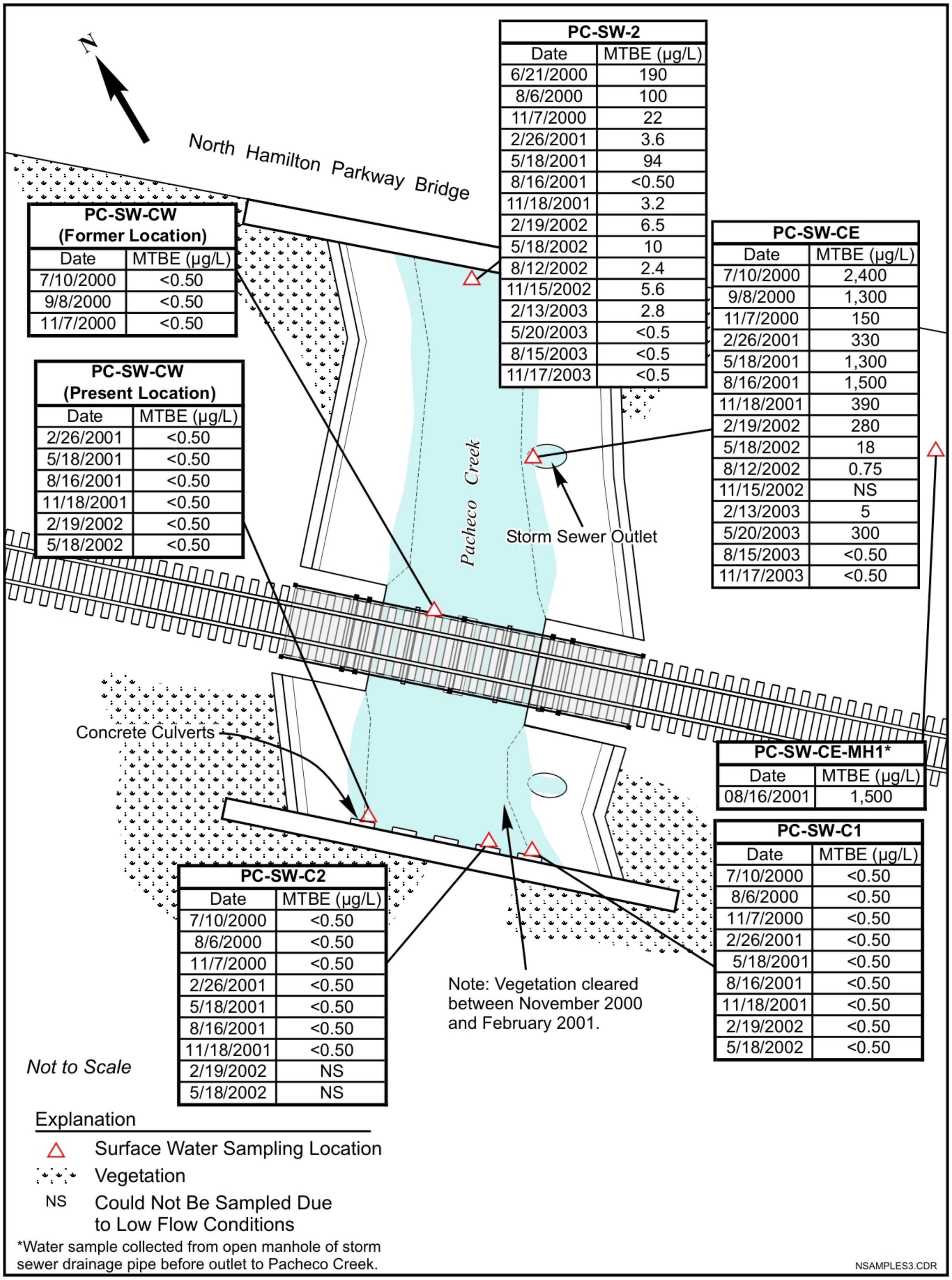
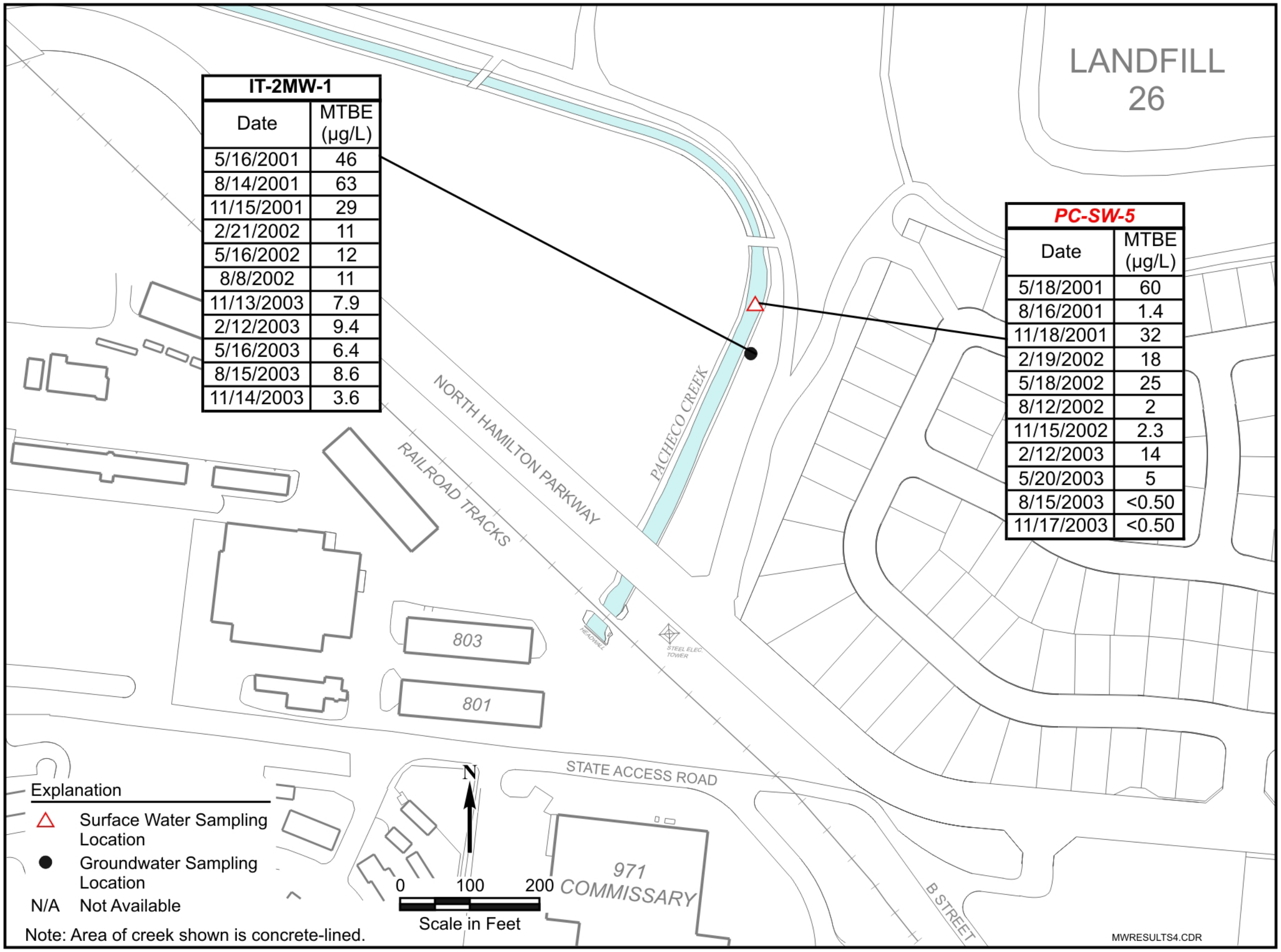


Figure 23. MTBE Concentrations at Culvert Outlet Locations



IT-2MW-1

Date	MTBE (µg/L)
5/16/2001	46
8/14/2001	63
11/15/2001	29
2/21/2002	11
5/16/2002	12
8/8/2002	11
11/13/2003	7.9
2/12/2003	9.4
5/16/2003	6.4
8/15/2003	8.6
11/14/2003	3.6

PC-SW-5

Date	MTBE (µg/L)
5/18/2001	60
8/16/2001	1.4
11/18/2001	32
2/19/2002	18
5/18/2002	25
8/12/2002	2
11/15/2002	2.3
2/12/2003	14
5/20/2003	5
8/15/2003	<0.50
11/17/2003	<0.50

Figure 24. Comparison of MTBE Surface Water and Groundwater Concentrations

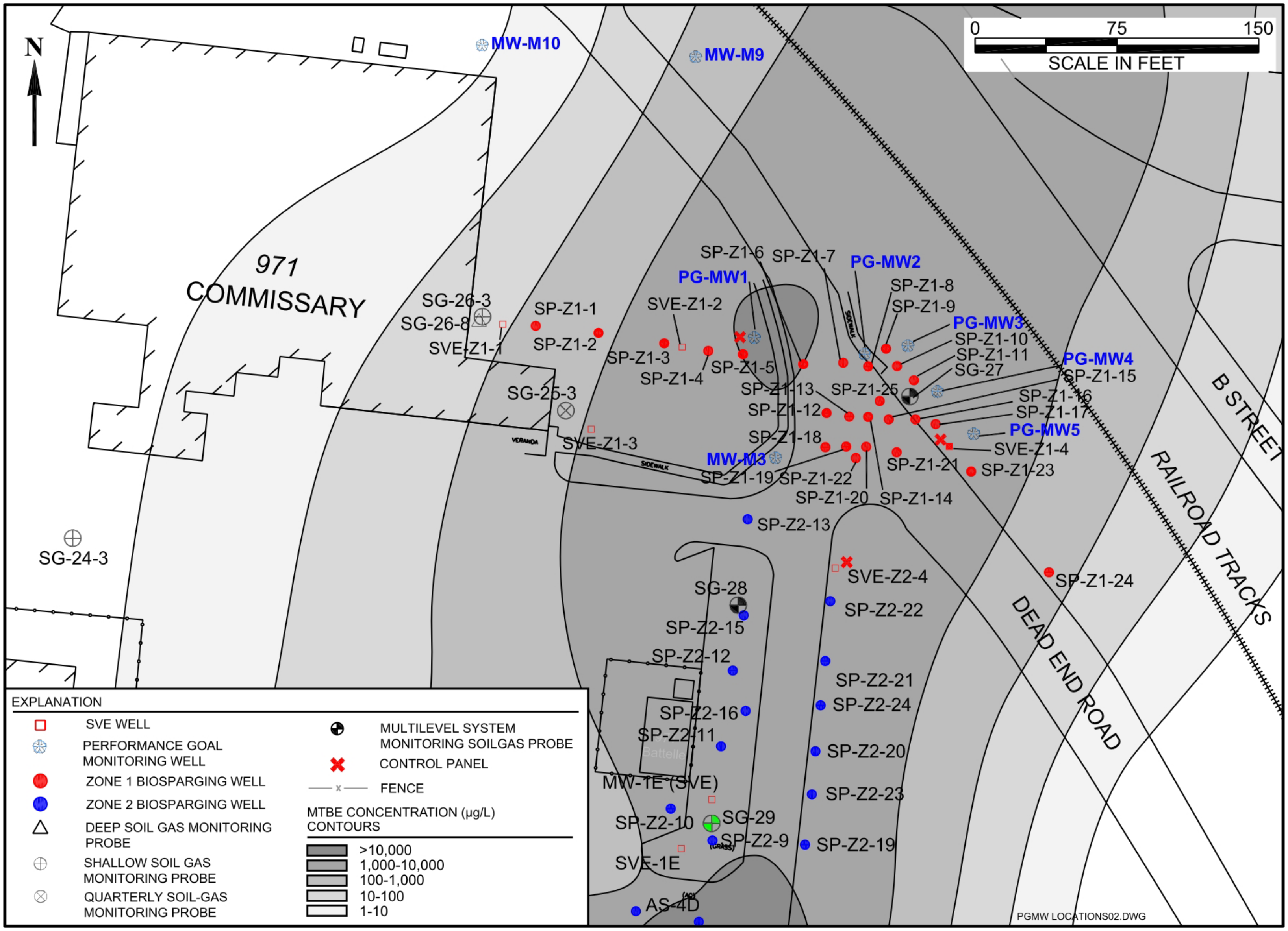


Figure 25. Performance Goal Monitoring Well Locations

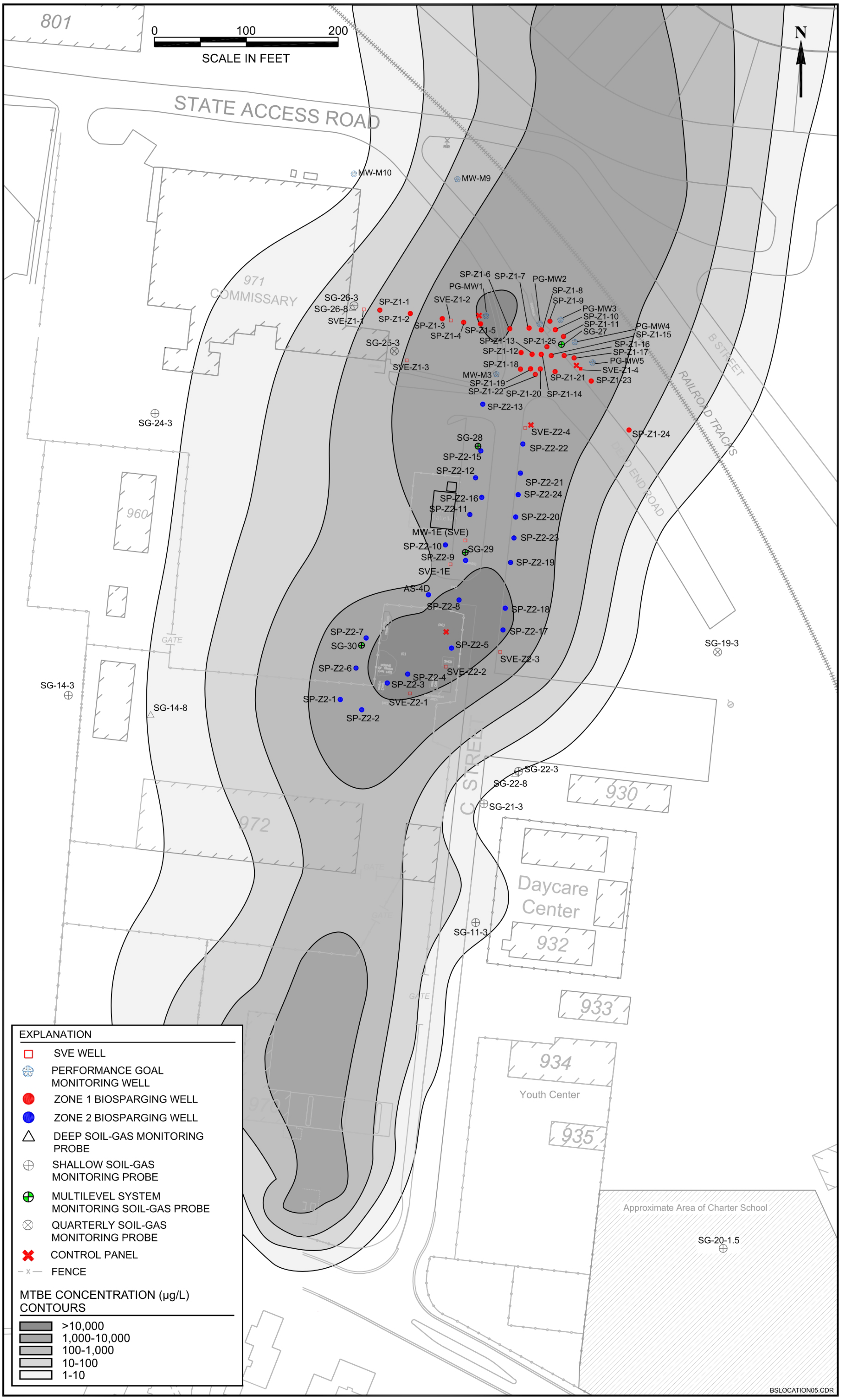


Figure 26. Biosparging System Layout

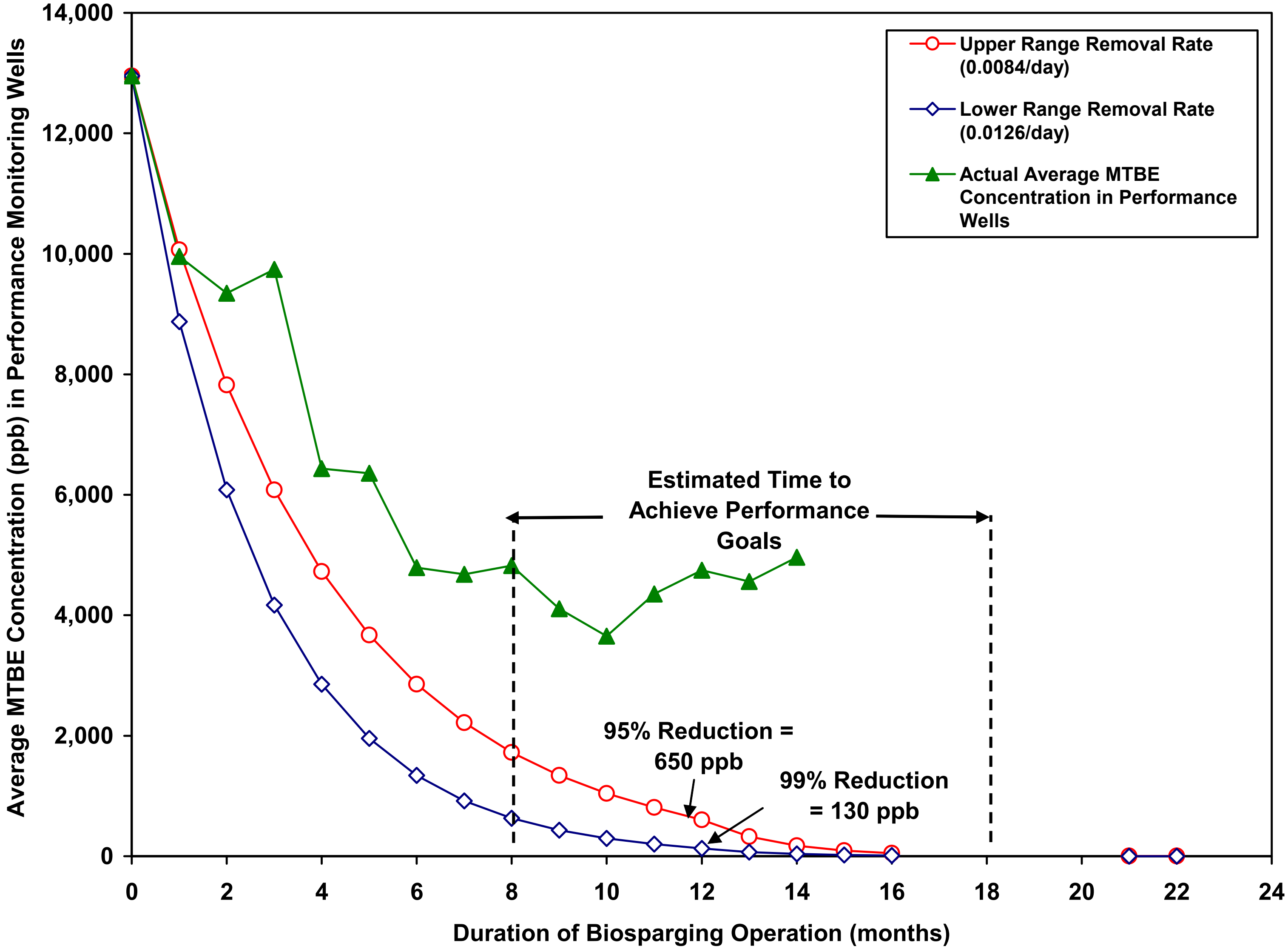


Figure 27. Actual Versus Expected Average MTBE Concentration Trends in Performance Goal Monitoring Wells

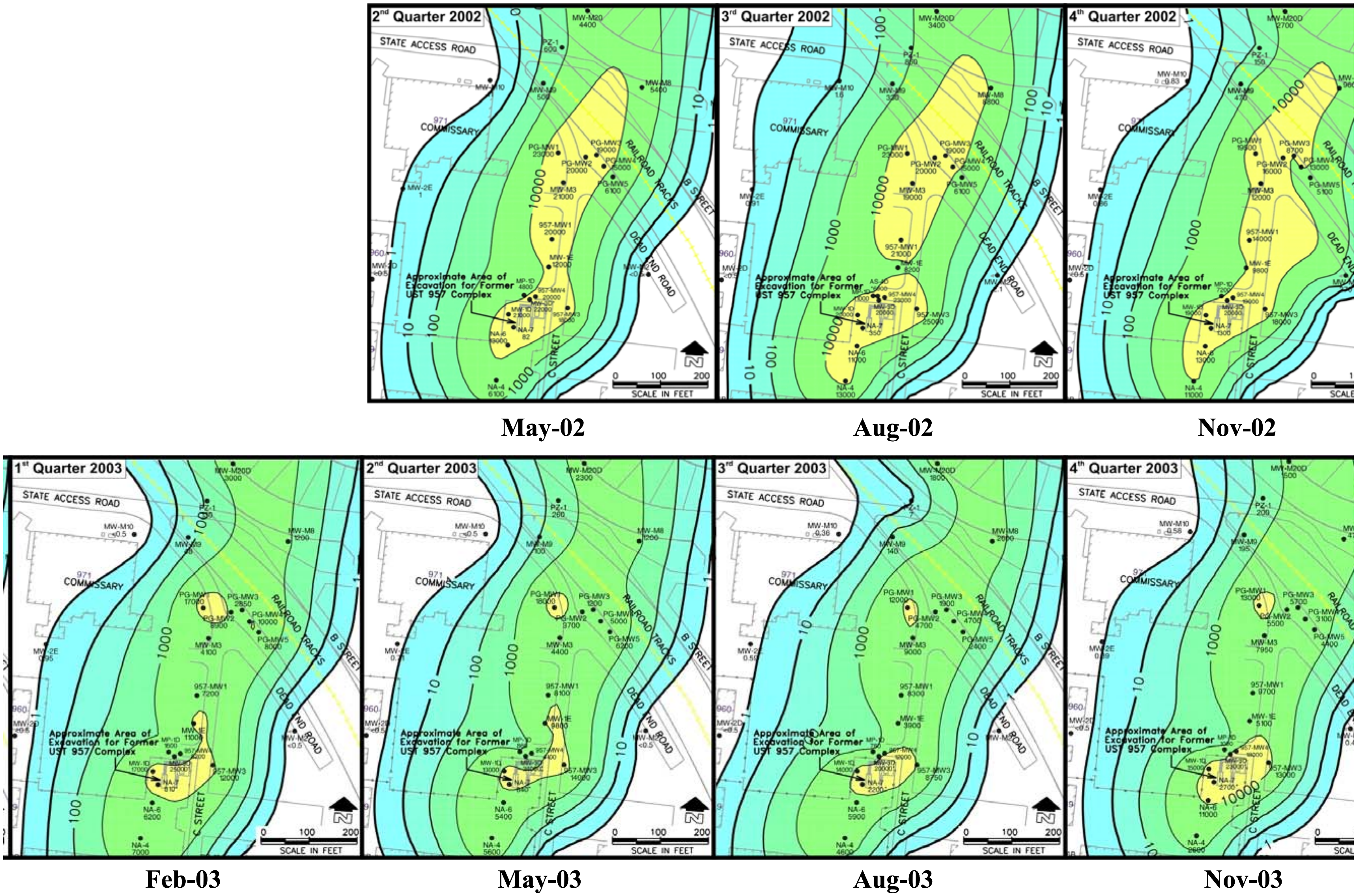


Figure 28. MTBE Plume Contours in the Biosparging Treatment Area

TABLES

Table 1. Groundwater Monitoring Network and Decision Criteria by Objective[a]

Location	Monitoring Wells	Decision Criteria
Transect		
Area A (970 Source Area)	970-MW1, MW-5A, MW-6A, MW-1A, MW-7A	Concentration trends which show a general decrease or do not increase over time indicate that a continuing source to groundwater does not exist; consistently increasing concentrations indicate that a potential source to groundwater exists.
Area D (957 Source Area)	MW-1D, MP-1D, 957-MW4, 957-MW3	
Area B	MW-4B, MW-1B, 970-MW4, MW-3B	If consistently increasing concentrations are observed, the potential impacts to downgradient receptors will be evaluated; consistently decreasing or stable concentrations indicate that internal plume migration is not occurring in these areas.
Property boundary (State Access Road)	MW-M1, MW-M10, MW-M9, MW-M8, MW-M16	
Downgradient MTBE transect	IT-2MW-2, IT-1MW-4A, IT-MW-92-38, IT-MW-92-39, MW-M25 (S and D)	
Perimeter		
Benzene plume perimeter	NA-0, 970-MW1, 970-MW2, 957-MW1, 957-MW3, 970-MW3, MW-3B, MW-10A	Concentrations remaining below detection limits at perimeter wells of the respective plumes indicate that the extent of the plume is not expanding; if benzene and/or MTBE is consistently detected in wells in which they previously had not been detected, this may be an indication of potential plume migration.
MTBE plume perimeter	NA-0, MW-4B, MW-6B, MW-2D, MW-2E, MW-M1, PZ-3, PZ-4, MW-M19, MW-M11, IT-2MW-2, IT-PZ-5, MW-M12, MW-M13, IT-GMP-17, IT-GMP-18, IT-EW-91-1, IT-MW-81S, IT-MW-81D, MW-M25 (S and D), MW-M24, MW-M16, MW-M2, 970-MW3, MW-3B	
Centerline		
Centerline of plume from NA-0 to IT-GMP-18 (approximately 3,000 ft downgradient)	NA-0, NA-1, MW-1A, 970-MW5, MW-4A, 970-MW4, NA-4, NA-6, NA-7, 957-MW4, MW-1E, 957-MW1, MW-M3, MW-M9, PZ-1, IT-MW-92-38, MW-M20 (S and D), MW-M21, MW-M22, MW-M23, IT-PZ-9, IT-GMP-17, IT-GMP-18	Concentrations will be compared to established risk levels to ensure that they are within acceptable levels; if consistent increases in concentration are observed, a determination of the potential impacts will be made and the monitoring network reevaluated.
Development Area MTBE Monitoring		
Development area north of Navy Property	PZ-1, PZ-3, PZ-4, MW-M11, MW-M15, IT-2MW-1, IT-PZ-5, IT-2MW-2, IT-1MW-4A, IT-MW-92-38, IT-MW-92-39, IT-GMP-15, EW-91-1, MW-M12, IT-PZ-7, MW-M13, IT-PZ-9, IT-GMP-17, MW-M14 (S and D), MW-M17, MW-M18, MW-M19, MW-M20 (S and D), MW-M21, MW-M22, MW-M23, MW-M24, MW-M25 (S and D), MW-M26 (S and D), MW-M27 (S and D), IT-GMP-16, IT-GMP-18, IT-MW-81 (S and D), MW-M8, MW-M16	MTBE concentrations will be compared to residential risk values to ensure that concentrations are protective of future residents; consistently increasing concentrations (one full cycle) will indicate internal migration of the plume.

Table 1. Groundwater Monitoring Network and Decision Criteria by Objective (Continued)

Location	Monitoring Wells	Decision Criteria
Special Features		
Northbay Children's Center	970-MW3, MW-3B, PZ-10, PZ-11	If concentrations do not exceed residential risk levels, no further action is warranted; if changing concentrations indicate that risk levels will likely be exceeded in the future, further evaluation or more extensive monitoring may be warranted.
Property boundary (State Access Road)	MW-M1, MW-M10, MW-M9, MW-M8, MW-M16	Consistently increasing concentrations (one full cycle) will be indicative of internal plume migration; consistently decreasing or stable concentrations (one full cycle) will indicate that elevated concentrations are not migrating across the property boundary.
Pacheco Creek vicinity	IT-PZ-5, IT-2MW-2, IT-1MW-4A, IT-2MW-1, MW-M17, MW-M18	Decreasing concentrations will indicate that the extent of impact to Pacheco Creek will likely decrease; increasing concentrations will indicate that future impact to Pacheco Creek may increase (if the surrounding groundwater is in fact the source of impact).
Bedrock wells	MW-9A, MW-3D	Comparison of constituent concentrations detected in bedrock wells to nearby shallower screened wells will determine impact to fractured bedrock.
Former UST 970-3 tank pit excavation	MW-8A	Concentration trends, which show a general decrease or do not increase over time, indicate that a continuing source to groundwater does not exist; consistently increasing concentrations indicate that a potential source to groundwater exists.
Nested well pairs	MW-M14 (S and D), MW-M20 (S and D), MW-M25 (S and D), MW-M26 (S and D), MW-M27 (S and D)	Comparable concentrations between samples from shallow and deep intervals indicate that MTBE is distributed equally between upper and lower aquifer zones; varying concentrations indicate stratification of MTBE in the aquifer zone which could potentially be associated with surface water infiltration.

(a) This table updates the original groundwater monitoring network provided in Table 3 of the *Groundwater Monitoring Plan* (Battelle, 2000a).

Table 2. Sampling and Analytical Methods

Analyte	Method	Container	Sample Size	Preservation	Holding Time
Groundwater					
BTEX, MTBE, TBA[(a)], TBF, ETBE, TAME, DIPE	SW-8260B	Borosilicate glass	3 × 40 mL VOA vials[(c)]	HCl to pH <2, @ 4°C	14 days
TPH (purgeable)	*California LUFT Manual*[(b)]	Borosilicate glass	3 × 40 mL VOA vials[(c)]	HCl to pH <2, @ 4°C	14 days
Surface Water					
BTEX, MTBE	SW-8260B	Borosilicate glass	3 × 40 mL VOA vials	HCl to pH <2, @ 4°C	14 days

(a) Sample collected without the preservative HCl.
(b) Source: CSWRCB, 1989.
(c) One set of three VOA vials is sufficient for all groundwater analysis with the exception of additional VOA vials collected for lower laboratory detection limits
LUFT – Leaking Underground Fuel Tank

Table 3. Laboratory Practical Quantitation Limits Based on Clean Matrices

Analyte	Reporting Limit for Water
TPH (purgeable)	0.05 mg/L
BTEX	0.5 µg/L
MTBE	0.5 µg/L
TBA	10 µg/L
TBF	5 µg/L
ETBE	2 µg/L
TAME	1 µg/L
DIPE	2 µg/L

Table 4. QC Samples

Type of Sample	Number of Samples
Field duplicates	10% of total samples collected
Equipment rinsate[(a)]	20% of total samples collected
Trip blank	1 per cooler
Field blank	1 per day
Laboratory QA[(b)]	5%

(a) Required to verify decontamination between samples where nondedicated equipment is used.
(b) For matrix spike/matrix spike duplicate analysis.

Table 5. Groundwater Monitoring Analytical Program[a]

Well ID	TPH-G (Method: *California LUFT Manual* [CSWRCB, 1989])	BTEX and MTBE (EPA Method 8260B)	TBA, TBF, ETBE, TAME, DIPE (8260B)	3 VOAs HCl	4 VOAs HCl	3 VOAs unpreserved
MW-1A[b]	x	x	x		x	x
MW-4A[b]	x	x			x	
MW-5A[b]	x	x	x		x	x
MW-6A	x	x	x		x	x
MW-7A	x	x	x		x	x
MW-8A	x	x			x	
MW-9A	x	x			x	
MW-10A[b]	x	x	x		x	x
MW-1B[b]	x	x			x	
MW-3B	x	x	x		x	x
MW-4B[b]	x	x			x	
MW-6B[b]	x	x			x	
MW-1D	x	x	x		x	x
MW-2D	x	x			x	
MW-3D[c]	x	x			x	
MP-1D[c]	x	x	x		x	x
MW-1E	x	x			x	
MW-2E	x	x			x	
957-MW1	x	x	x		x	x
957-MW3	x	x	x		x	x
957-MW4[c]	x	x	x		x	x
970-MW1[b]	x	x	x		x	x
970-MW2[b]	x	x	x		x	x
970-MW3	x	x	x		x	x
970-MW4[b],[d]	x	x	TBA/TBF		x	x
970-MW5[b]	x	x			x	
NA-0[b]	x	x	x		x	x
NA-1	x	x	-		x	
NA-4	x	x	-		x	
NA-6	x	x	-		x	
NA-7	x	x	-		x	
PZ-1	-	x	-	x		

Table 5. Groundwater Monitoring Analytical Program[a] (Continued)

Well ID	TPH-G (Method: *California LUFT Manual* [CSWRCB, 1989])	BTEX and MTBE (EPA Method 8260B)	TBA, TBF, ETBE, TAME, DIPE (8260B)	3 VOAs HCl	4 VOAs HCl	3 VOAs unpreserved
PZ-3	-	x	-	x		
PZ-4[b]	-	x	-	x		
PZ-10	x	x	-		x	
PZ-11	-	x	-	x		
MW-M1	-	x	-	x		
MW-M2	-	x	-	x		
MW-M3[d]	x	x	TBA/TBF		x	x
MW-M8[d]	-	x	TBA/TBF	x		x
MW-M9[d]	-	x	TBA/TBF	x		x
MW-M10[d]	-	x	TBA/TBF	x		x
MW-M11[b]	-	x	-	x		
MW-M12[b]	-	x	-	x		
MW-M13	-	x	-	x		
MW-M14D	-	x	-	x		
MW-M14S	-	x	-	x		
MW-M15	-	x	-	x		
MW-M16	-	x	-	x		
MW-M17	-	x	-	x		
MW-M18	-	x	-	x		
MW-M19	-	x	-	x		
MW-M20D	-	x	-	x		
MW-M20S[e]	-	x	-	x		
MW-M21	-	x	-	x		
MW-M22	-	x	-	x		
MW-M23	-	x	-	x		
MW-M24[b]	-	x	-	x		
MW-M25D[b]	-	x	-	x		
MW-M25S[e]	-	x	-	x		
MW-M26D	-	x	-	x		
MW-M26S[e]	-	x	-	x		
MW-M27D[b]	-	x	-	x		
MS-M27S[e]	-	x	-	x		
IT-PZ-5	-	x	-	x		
IT-PZ-7	-	x	-	x		

Table 5. Groundwater Monitoring Analytical Program[(a)] (Continued)

Well ID	TPH-G (Method: *California LUFT Manual* [CSWRCB, 1989])	BTEX and MTBE (EPA Method 8260B)	TBA, TBF, ETBE, TAME, DIPE (8260B)	3 VOAs HCl	4 VOAs HCl	3 VOAs unpreserved
IT-PZ-9	-	x	-	x		
IT-1MW-4A	-	x	-	x		
IT-GMP-15	-	x	-	x		
IT-GMP-16	-	x	-	x		
IT-GMP-17	-	x	-	x		
IT-GMP-18	-	x	-	x		
IT-MW92-38	-	x	-	x		
IT-MW92-39	-	x	-	x		
EW91-1[(b)]	-	x	-	x		
IT-2MW-1	-	x	-	x		
IT-2MW-2[(b)]	-	x	-	x		
IT-MW-81D	-	x	-	x		
IT-MW-81S[(b)]	-	x	-	x		
PG-MW1[(d)]	-	x	TBA/TBF	x		x
PG-MW2[(d)]	-	x	TBA/TBF	x		x
PG-MW3[(d)]	-	x	TBA/TBF	x		x
PG-MW4[(d)]	-	x	TBA/TBF	x		x
PG-MW5[(d)]	-	x	TBA/TBF	x		x
PC-SW-1	-	x	-	x		
PC-SW-2	-	x	-	x		
PC-SW-3	-	x	-	x		
PC-SW-4	-	x	-	x		
PC-SW-5	-	x	-	x		
PC-SW-CE	-	x	-	x		

(a) This table updates the original groundwater monitoring analytical program provided in Table 2 of the *Groundwater Monitoring Plan* (Battelle, 2000a).
(b) Semiannual monitoring (November and May quarterly monitoring events).
(c) Inorganic parameters (sulfate, chloride, alkalinity, calcium, magnesium, sodium, potassium) and metals. Require 1 preserved 250 mL plastic bottle, 1 unpreserved. Both should be field-filtered before sent to lab.
(d) Performance monitoring (MTBE, BTEX, TBA/TBF, acetone)
(e) Annual monitoring (November monitoring event).

Table 6. Historical Maximum and Average Concentrations of MTBE and Benzene

Date	MTBE (μg/L)		Benzene (μg/L)	
	Maximum	Average	Maximum	Average
Nov-96[(a)]	240,000	73,568	12,000	2,128
Mar-98[(a)]	77,000	24,004	9,400	1,436
May-98	280,000	32,058	14,000	1,791
Aug-98	140,000	21,645	10,000	1,002
Nov-98	130,000	19,288	11,000	982
Feb-99	84,000	12,360	4,300	418
May-99	140,000	16,762	6,300	368
Aug-99[(b)]	78,000	9,214	3,900	198
Nov-99	82,000	10,925	4,000	139
Feb-00[(b)]	65,000	9,425	2,200	114
May-00	61,000	8,162	1,500	94
Aug-00	43,000	5,135	2,300	83
Nov-00[(c)]	35,000 [(d)]	4,700	1,600	40
Feb-01	43,000	3,779	660	31
May-01	33,000	3,268	350	15
Aug-01	45,000	4,684	250	16
Nov-01	32,000	3,316	300	18
Feb-02	26,000	2,374	230	10
May-02	22,000	2,518	120	11
Aug-02[(e)]	25,000	3,391	130	8
Nov-02	20,000	2,441	240	9
Feb-03	25,000	1,950	65	5
May-03	24,000	1,593	150	6
Aug-03	20,000	1,964	110	5
Nov-03	23,000	1,776	230	7

(a) Prior to system installation. Only nine existing wells.
(b) Monitoring well network modified due to well abandonment.
(c) Monitoring well network modified due to installation of replacement wells.
(d) A duplicate sample was collected from this well and reported an MTBE concentration of 29,000 μg/L.
(e) Monitoring well network modified according to recommendations in the *Annual Site Status Report (for the Year 2001)* (Battelle, 2002a).

Table 7. Bedrock Well and Nearby Monitoring Well Sampling Results

Bedrock Well ID	Sample Date	MTBE (µg/L)	Benzene (µg/L)	Nearby Monitoring Well ID	Sample Date	MTBE (µg/L)	Benzene (µg/L)
MW-9A	10/21/00	220	<2.0	MW-5A	NS	NS	NS
	11/17/00[a]	120/120	<2.0/<2.0		11/13/00	2,300	2.0
	3/1/01	600	16		2/25/01	1,100	<1.0
	5/22/01	350	<1.3		5/16/01	380	0.57
	8/19/01	310	<0.5		8/14/01	330	<0.5
	11/19/01	260	<0.5		11/18/01	530	1.9
	2/21/02	530	<0.5		2/19/02	330	<0.5
	5/20/02	390	<0.5		5/21/02	170	0.23 J
	8/11/02	330	<5		8/11/02	130	<5
	11/17/02	310	<0.5		11/17/02	250	<0.5
	2/10/03	290	<0.5		2/10/03	250	<0.5
	5/21/03	300	<0.5		5/13/03	200	<0.5
	8/12/03	270	<0.5		NS	NS	NS
	11/15/03	150	<0.5		11/10/03	110	<0.5
MW-3D	10/21/00	25,000	<10	957-MW4	NS	NS	NS
	11/17/00	34,000	<10		11/15/00	34,000	2.7
	2/28/01	43,000	<20		2/25/01	10,000	<1.0
	5/22/01	28,000	<2.5		5/14/01	30,000	<0.5
	8/19/01[a]	31,000/34,000	<2.5/<2.5		8/14/01	39,000	<6.3
	11/19/01[a]	25,000/26,000	<2.5/<2.5		11/18/01	32,000	<2.5
	2/20/02	26,000	<5.0		2/18/02	13,000	<1.0
	5/20/02	22,000	<120		5/20/02	20,000	<0.5
	8/12/02	20,000	<2.5		8/12/02	23,000	<2.5
	11/12/02	20,000	<2.5		11/12/02	19,000	<2.5
	2/5/03	25,000	<0.5		2/5/03	5,200	<0.5
	5/8/03	24,000	<2.5		5/8/03	4,100	<0.5
	8/11/03	20,000	<0.5		8/11/03	12,000	<0.5
	11/6/03	23,000	<0.5		11/6/03	18,000	<0.5
MW-2E-BR	12/4/03	0.46 J	<0.5	MW-2E	11/15/03	0.89	<0.5
MW-M2-BR	12/4/03	140	<0.5	MW-M2	11/15/03	0.4 J	<0.5
MW-M8-BR	12/4/03	19	<0.5	MW-M8	11/15/03	4,700	<0.5

(a) Results of duplicate sample are shown.
J = estimated value below the detection limit of 0.5 µg/L
NS = not sampled.

Table 8. Nested Well Sampling Results

Sample ID[(a)]	Sample Date	MTBE (μg/L)	Benzene (μg/L)	Toluene (μg/L)	Ethylbenzene (μg/L)	Total Xylenes (μg/L)
November 2000						
MW-M14S	11/7/00	13	<2.5	<2.5	<2.5	<2.5
MW-M14D	11/8/00	11	<0.5	<0.5	<0.5	<0.5
MW-M20S[(b)]	NS	NS	NS	NS	NS	NS
MW-M20D	11/16/00	2,000	<1.0	<1.0	<1.0	<1.0
MW-M25S	11/14/00	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M25D	11/15/00	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M26S	11/14/00	280	<0.5	<0.5	<0.5	<0.5
MW-M26D	11/15/00	280	<0.5	<0.5	<0.5	<0.5
MW-M27S	11/9/00	<1.3	<1.3	<1.3	<1.3	<1.3
MW-M27D	11/10/00	1.3	<0.5	<0.5	<0.5	<0.5
February 2001						
MW-M14S	2/27/01	39	<10	<10	<10	<20
MW-M14D	2/28/01	30	<0.05	<0.5	<0.5	<1.0
MW-M20S[(b)]	NS	NS	NS	NS	NS	NS
MW-M20D	2/26/01	5,600	<0.5	0.58	<0.5	<1.0
MW-M25S	2/27/01	<10	<10	<10	<10	<20
MW-M25D	2/28/01	<0.5	<0.5	<0.5	<0.5	<1.0
MW-M26S	2/27/01	370	<0.5	<0.5	<0.5	<1.0
MW-M26D	2/28/01	320	<0.5	<0.5	<0.5	<1.0
MW-M27S	2/27/01	1.7	<0.5	<0.5	<0.5	<1.0
MW-M27D	2/28/01	1.7	<0.5	<0.5	<0.5	<1.0
May 2001						
MW-M14S	5/15/01	46	<5.0	<5.0	<5.0	<5.0
MW-M14D	5/17/01	30	<0.5	<0.5	<0.5	<0.5
MW-M20S[(b)]	NS	NS	NS	NS	NS	NS
MW-M20D	5/18/01	4,100	<0.5	<0.5	<0.5	<0.5
MW-M25S	5/15/01	<2.5	<2.5	<2.5	<2.5	<2.5
MW-M25D	5/21/01	<0.5	<0.5	0.52	<0.5	<0.5
MW-M26S	5/15/01	200	<0.5	<0.5	<0.5	<0.5
MW-M26D	5/17/01	180	<0.5	0.91	<0.5	<0.5
MW-M27S	5/15/01	1.1	<0.5	<0.5	<0.5	<0.5
MW-M27D	5/17/01	1.0	<0.5	1.1	<0.5	<0.5
August 2001						
MW-M14S	8/14/01	56	<2.5	<2.5	<2.5	<2.5
MW-M14D	8/15/01	44	<0.5	1.8	<0.5	<0.5
MW-M20S[(b)]	NS	NS	NS	NS	NS	NS
MW-M20D	8/18/01	6,900	<0.5	1.6	<0.5	<0.5
MW-M25S	8/14/01	<0.5	<0.5	0.73	<0.5	<0.5
MW-M25D	8/16/01	<0.5	<0.5	1.4	<0.5	<0.5
MW-M26S	8/14/01	310	<0.5	<0.5	<0.5	<0.5
MW-M26D	8/15/01	320	<0.5	1.6	<0.5	<0.5
MW-M27S	8/14/01	1.5	<0.5	<0.5	<0.5	<0.5
MW-M27D	8/15/01	1.3	<0.5	2.2	<0.5	<0.5
November 2001						
MW-M14S	11/16/01	91	<1.0	<1.0	<1.0	<1.0
MW-M14D	11/19/01	58	<0.5	<0.5	<0.5	<0.5
MW-M20S[(b)]	NS	NS	NS	NS	NS	NS
MW-M20D	11/19/01	5,200	<0.5	<0.5	<0.5	<0.5

Table 8. Nested Well Sampling Results (Continued)

Sample ID[a]	Sample Date	MTBE (μg/L)	Benzene (μg/L)	Toluene (μg/L)	Ethylbenzene (μg/L)	Total Xylenes (μg/L)
MW-M25S	11/15/01	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M25D	11/19/01	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M26S	11/17/01	310	<0.5	<0.5	<0.5	<0.5
MW-M26D	11/19/01	330	<0.5	<0.5	<0.5	<0.5
MW-M27S	11/14/01	1.7	<0.5	<0.5	<0.5	<0.5
MW-M27D	11/19/01	1.2	<0.5	<0.5	<0.5	<0.5
February 2002						
MW-M14S	2/23/02	79	<1.0	<1.0	<1.0	<1.0
MW-M14D	2/25/02	130	<0.5	<0.5	<0.5	<0.5
MW-M20S	2/23/02	22	<0.5	<0.5	<0.5	<0.5
MW-M20D	2/25/02	5,600	<0.5	<0.5	<0.5	<0.5
MW-M25S	2/22/02	<1.0	<1.0	<1.0	<1.0	<1.0
MW-M25D	2/25/02	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M26S	2/23/02	280	<0.5	<0.5	<0.5	<0.5
MW-M26D	2/25/02	340	<0.5	<0.5	<0.5	<0.5
MW-M27S	2/22/02	1.7	<0.5	<0.5	<0.5	<0.5
MW-M27D	2/25/02	1.9	<0.5	<0.5	<0.5	<0.5
May 2002						
MW-M14S	5/13/02	54	<0.5	<0.5	<0.5	<1.0
MW-M14D	5/14/02	170	<0.5	<0.5	<0.5	<1.0
MW-M20S	5/17/02	18	<0.5	<0.5	<0.5	<1.0
MW-M20D	5/18/02	4,400	<250	<250	<250	<500
MW-M25S	5/15/02	<0.5	<0.5	<0.5	<0.5	<1.0
MW-M25D	5/16/02	<0.5	<0.5	<0.5	<0.5	<1.0
MW-M26S	5/15/02	360	<0.5	<0.5	<0.5	<1.0
MW-M26D	5/16/02	430	<0.5	<0.5	<0.5	<1.0
MW-M27S	5/15/02	1.6	<0.5	<0.5	<0.5	<1.0
MW-M27D	5/16/02	1.7	<0.5	<0.5	<0.5	<1.0
August 2002[c]						
MW-M14D	8/7/02	170	<0.5	<0.5	<0.5	<1.0
MW-M20D	8/6/02	3,400	<0.5	<0.5	<0.5	<1.0
MW-M25D	8/7/02	<0.5	<0.5	<0.5	<0.5	<1.0
MW-M26D	8/6/02	320	<0.5	<0.5	<0.5	<1.0
MW-M27D	8/8/02	1.7	<0.5	<0.5	<0.5	<1.0
November 2002						
MW-M14S	11/15/02	52	<0.5	<0.5	<0.5	<1.0
MW-M14D	11/18/02	280	<0.5	<0.5	<0.5	<1.0
MW-M20S	11/16/02	23	<0.5	<0.5	<0.5	<1.0
MW-M20D	11/13/02	2,700	<0.5	<0.5	<0.5	<1.0
MW-M25S	11/14/02	<0.5	<0.5	<0.5	<0.5	<1.0
MW-M25D	11/18/02	<0.5	<0.5	<0.5	<0.5	<1.0
MW-M26S	11/14/02	410	<0.5	<0.5	<0.5	<1.0
MW-M26D	11/16/02	350	<0.5	<0.5	<0.5	<1.0
MW-M27S	11/14/02	2.1	<0.5	<0.5	<0.5	<1.0
MW-M27D	11/18/02	2.5	<0.5	<0.5	<0.5	<1.0
February 2003[c]						
MW-M14D	2/11/03	310	<0.5	0.24	<0.5	<0.5
MW-M20D	2/13/03	3,000	<0.5	<0.5	<0.5	<0.5
MW-M25D	2/11/03	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M26D	2/11/03	360	<0.5	<0.5	<0.5	<0.5

Table 8. Nested Well Sampling Results (Continued)

Sample ID[(a)]	Sample Date	MTBE (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)
MW-M27D	2/11/03	2.2	<0.5	<0.5	<0.5	<0.5
May 2003[(d)]						
MW-M14S	5/15/03	120	<0.5	<0.5	<0.5	<0.5
MW-M14D	5/16/03	360	<0.5	<0.5	<0.5	<0.5
MW-M20D	5/20/03	2300	<0.5	<0.5	<0.5	<0.5
MW-M25D	5/15/03	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M26D	5/16/03	290	<0.5	<0.5	<0.5	<0.5
MW-M27D	5/14/03	2.4	<0.5	<0.5	<0.5	<0.5
August 2003						
MW-M14S	8/15/03	87	<0.5	<0.5	<0.5	<0.5
MW-M14D	8/13/03	480	<0.5	<0.5	<0.5	<0.5
MW-M20D	8/14/03	1800	<0.5	<0.5	<0.5	<0.5
MW-M25D	NS	NS	NS	NS	NS	NS
MW-M26D	8/15/03	240	<0.5	<0.5	<0.5	<0.5
MW-M27D	NS	NS	NS	NS	NS	NS
November 2003						
MW-M14S	11/13/03	210	<0.5	<0.5	<0.5	<0.5
MW-M14D	11/12/03	400	<0.5	<0.5	<0.5	<0.5
MW-M20S	11/15/03	110	<0.5	<0.5	<0.5	<0.5
MW-M20D	11/13/03	1500	<0.5	<0.5	<0.5	<0.5
MW-M25S	11/12/03	<0.5	<0.5	0.49 J	<0.5	0.43 J
MW-M25D	11/11/03	<0.5	<0.5	<0.5	<0.5	<0.5
MW-M26S	11/13/03	380	<0.5	0.84	0.28 J	1.93
MW-M26D	11/12/03	290	<0.5	<0.5	<0.5	<0.5
MW-M27S	11/14/03	2.8	<0.5	<0.5	<0.5	<0.5
MW-M27D	11/11/03	2.8	<0.5	<0.5	<0.5	<0.5

NS = not sampled.

(a) S indicates shallow interval; D indicates deep interval.

(b) MW-M20S was not sampled during this quarterly monitoring event due to dryness.

(c) Shallow wells not sampled due to changes in monitoring requirements as presented in Table 13 of the *Annual Site Status Report (for the Year 2001)* (Battelle, 2002a).

(d) Sampling of shallow wells MW-M20S, MW-M25S, MW-M26S, and MW-M27S has been changed to annually, whereas MW-M14S has been changed from semiannually to quarterly as presented in Table 12 of the *Annual Site Status Report (for the Year 2002)* (Battelle, 2003a).

Table 9. Dissolved MTBE and Benzene Mass Estimates

Date	Dissolved MTBE Mass (kg)	Dissolved Benzene Mass (kg)
May-98[a]	N/A	5.0
Aug-98[a]	N/A	3.9
Nov-98[a]	287	3.4
Jan-99[a]	256	2.3
May-99[a]	277	1.8
Aug-99[b]	183	0.91
Nov-99	163	0.52
Feb-00[b]	126	0.74
May-00	118	0.74
Aug-00	73	0.44
Nov-00[c]	115	0.26
Feb-01	156	0.34
May-01	120	0.18
Aug-01	138	0.09
Nov-01	119	0.09
Feb-02	148	0.11
May-02	144	0.08
Aug-02	Not estimated [d]	Not estimated [d]
Nov-02	124	0.05
Feb-03	Not estimated [d]	Not estimated [d]
May-03	126	0.05
Aug-03	Not estimated [d]	Not estimated [d]
Nov-03	126	0.03

N/A = not applicable (MTBE plume not fully delineated at this time).
(a) Estimated mass of MTBE and benzene was modified from past estimates using consistent methods and refinements to improve the data quality for each sampling event.
(b) Monitoring well network modified due to well abandonment.
(c) Monitoring well network modified due to installation of replacement wells.
(d) Mass estimates not calculated for this sampling quarter as a result of changes in monitoring requirements as presented in Table 13 of the *Annual Site Status Report (for the Year 2001)* (Battelle, 2002a).

Table 10. Surface Water Monitoring Network and Decision Criteria[(a)]

Location	Sample ID	Objective	Decision Criteria
Upstream of Site	PC-SW-1	Establish concentrations in Pacheco Creek before it encounters the Site	MTBE concentrations detected upgradient of the Site indicate that another source is contributing to MTBE in Pacheco Creek.
Within the MTBE plume (just after outfall from culvert)	PC-SW-2	Determine if MTBE enters the creek along its subsurface run	If MTBE concentrations at the outfall of the culvert are greater than concentrations at the upstream location, this indicates that MTBE is entering the creek through one of the culverts; the presence of MTBE at this location is not necessarily associated with Former UST Site 957/970 because other areas also drain into the creek.
Within the MTBE plume	PC-SW-5	Determine if MTBE-impacted groundwater interacts with surface water of Pacheco Creek in the area of IT-2MW-1	If MTBE concentrations at the surface water sampling location compare to those detected in IT-2MW-1 a determination can be made of groundwater-surface water interaction.
Immediately downstream of MTBE plume	PC-SW-3	Evaluate the presence and persistence of MTBE in Pacheco Creek	If MTBE concentrations decrease from the immediate downstream location to the further downstream location, this indicates that the processes of volatilization, photodegradation, biodegradation, and/or dilution are causing a reduction in MTBE concentrations in Pacheco Creek.
Further downstream of MTBE plume	PC-SW-4		
Individual culvert outlet upstream of PC-SW-2	PC-SW-CE	Identify MTBE concentrations in water originating from individual culverts entering the creek in this area	If MTBE is detected at the location of the culvert outfall, this indicates that it is a likely source of MTBE to Pacheco Creek.

(a) This table updates the original surface water monitoring network provided in Table 4 of the *Groundwater Monitoring Plan* (Battelle, 2000a).

Table 11. Tabulated Surface Water Sampling Results

Sample ID	Date	Benzene (μg/L)	Toluene (μg/L)	Ethylbenzene (μg/L)	Total Xylenes (μg/L)	MTBE (μg/L)
PC-SW-1	6/21/00	NA	NA	NA	NA	<0.50
	8/6/00	<0.50	<0.50	<0.50	<1.0	<0.50
	11/7/00	<0.50	<0.50	<0.50	<1.0	<0.50
	03/01/01	<0.50	<0.50	<0.50	<1.0	<0.50
	5/18/01	<0.50	<0.50	<0.50	<0.50	<0.50
	8/16/01	<0.50	<0.50	<0.50	<0.50	<0.50
	11/18/01	<0.50	<0.50	<0.50	<0.50	<0.50
	02/19/02	<0.50	<0.50	<0.50	<0.50	<0.50
	5/18/02	<0.50	<0.50	<0.50	<1.0	<0.50
	8/12/02	<0.50	<0.50	<0.50	<1.0	<0.50
	11/16/02	<0.50	<0.50	<0.50	<1.0	<0.50
	2/31/03	<0.50	<0.50	<0.50	<1.0	<0.50
	5/20/03	<0.50	<0.50	<0.50	<1.0	<0.50
	8/15/03	<0.50	<0.50	<0.50	<1.0	<0.50
	11/17/03	**<0.50**	**0.22 J**	**<0.50**	**<1.0**	**2.4**
PC-SW-2	6/21/00	NA	NA	NA	NA	190
	8/6/00	<0.50	<0.50	<0.50	<1.0	100
	11/7/00	<0.50	<0.50	<0.50	<1.0	22
	02/26/01	<0.50	<0.50	<0.50	<0.50	3.6
	5/18/01	<0.50	<0.50	<0.50	<0.50	94
	8/16/01	<0.50	<0.50	<0.50	<0.50	<0.50
	11/18/01	<0.50	<0.50	<0.50	<0.50	3.2
	02/19/02	<0.50	<0.50	<0.50	<0.50	6.5
	5/18/02	<0.50	<0.50	<0.50	<1.0	10
	8/12/02	<0.50	<0.50	<0.50	<1.0	2.4
	11/15/02	<0.50	<0.50	<0.50	<1.0	5.6
	2/13/03	<0.50	<0.50	<0.50	<1.0	2.8
	5/20/03	<0.50	<0.50	<0.50	<1.0	<0.50
	8/15/03	<0.50	<0.50	<0.50	<1.0	<0.50
	11/17/03	**<0.50**	**<0.50**	**<0.50**	**<1.0**	**<0.50**
PC-SW-3	11/7/00	<0.50	<0.50	<0.50	<1.0	6.0
	02/26/01	<0.50	<0.50	<0.50	<0.50	6.4
	5/18/01	<0.50	<0.50	<0.50	<0.50	22
	8/16/01	<0.50	<0.50	<0.50	<0.50	0.64
	11/18/01	<0.50	<0.50	<0.50	<0.50	17
	02/19/02	<0.50	<0.50	<0.50	<0.50	14
	5/18/02	<0.50	0.39 J	<0.50	<1.0	15
	8/12/02	<0.50	0.39 J	<0.50	<1.0	0.76
	11/15/02	<0.50	<0.50	<0.50	<1.0	21
	2/11/03	<0.50	<0.50	<0.50	<1.0	21
	5/20/03	<0.50	<0.50	<0.50	<1.0	4.9
	8/15/03	<0.50	<0.50	<0.50	<1.0	4
	11/17/03	**<0.50**	**<0.50**	**<0.50**	**<1.0**	**8.9**

Sample ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)
PC-SW-4	6/21/00	NA	NA	NA	NA	0.69
	8/6/00	<0.50	<0.50	<0.50	<1.0	<0.50
	11/7/00	<0.50	<0.50	<0.50	<1.0	0.60
	02/26/01	<0.50	<0.50	<0.50	<0.50	24
	5/18/01	<0.50	<0.50	<0.50	<0.50	0.85
	8/16/01	<0.50	<0.50	<0.50	<0.50	<0.50
	11/18/01	<0.50	<0.50	<0.50	<0.50	3.9
	02/19/02	<0.50	<0.50	<0.50	<0.50	15
	5/18/02	<0.50	<0.50	<0.50	<1.0	0.37 J
	8/12/02	<0.50	<0.50	<0.50	<1.0	<0.50
	11/15/02	<0.50	<0.50	<0.50	<1.0	5.8
	2/13/03	<0.50	<0.50	<0.50	<1.0	4.4
	5/20/03	<0.50	<0.50	<0.50	<1.0	1.3
	8/15/03	<0.50	<0.50	<0.50	<1.0	1.2
	11/17/03	**<0.50**	**<0.50**	**<0.50**	**<1.0**	**<0.50**
PC-SW-5	02/26/01	<0.50	<0.50	<0.50	<0.50	6.6
	5/18/01	<0.50	<0.50	<0.50	<0.50	60
	8/16/01	<0.50	<0.50	<0.50	<0.50	1.4
	11/18/01	<0.50	<0.50	<0.50	<0.50	32
	02/19/02	<0.50	<0.50	<0.50	<0.50	18
	5/18/02	<0.50	<0.50	<0.50	<1.0	25
	8/12/02	<0.50	<0.50	<0.50	<1.0	2
	11/15/02	<0.50	<0.50	<0.50	<1.0	2.3
	2/12/03	<0.50	0.32	<0.50	<1.0	14
	5/20/03	<0.50	<0.50	<0.50	<1.0	5
	8/15/03	<0.50	<0.50	<0.50	<1.0	<0.5
	11/17/03	**<0.50**	**<0.50**	**<0.50**	**<1.0**	**<0.5**
PC-SW-CE	7/10/00	NA	NA	NA	NA	2,400
	9/8/00	<0.50	<0.50	<0.50	<1.0	1,300
	11/7/00	<0.50	<0.50	<0.50	<1.0	150
	02/26/01	<0.50	<0.50	<0.50	<0.50	330
	5/18/01	<2.5	<2.5	<2.5	<2.5	1,300
	8/16/01	<2.5	<2.5	<2.5	<2.5	1,500
	11/18/01	<0.50	<0.50	<0.50	<0.50	390
	02/19/02	<0.50	<0.50	<0.50	<0.50	280
	5/18/02	<0.50	<0.50	<0.50	<1.0	18
	8/12/02	<0.50	<0.50	<0.50	<1.0	0.75
	11/15/02 (a)	NA	NA	NA	NA	NA
	2/13/03	<0.50	<0.50	<0.50	<1.0	5
	5/20/03	<0.50	<0.50	<0.50	<1.0	300
	8/15/03	<0.50	<0.50	<0.50	<1.0	<0.5
	11/17/03	**<0.50**	**<0.50**	**<0.50**	**<1.0**	**<0.5**

Boldface indicates current sampling event.
NA = not analyzed
(a) Sampling of PC-SW-CE was unintentionally omitted in the November 2002 sampling event.

Table 12. Soil-Gas Monitoring Probes and Identification Labels

Shallow Soil-Gas Monitoring Probes	Deep Soil-Gas Monitoring Probes	System Monitoring Soil-Gas Probes	RWQCB-Requested Quarterly Soil-Gas Monitoring Probes
SG-14-3 SG-20-1.5 SG-21-3 SG-22-3 SG-24-3 SG-11-3 SG-26-3	SG-14-8 SG-22-8 SG-26-8	SG-27-5.5 SG-27-8 SG-28-5.5 SG-28-9 SG-29-6 SG-29-9 SG-30-5.5 SG-30-8	SG-25-3 SG-19-3

Table 13. Schedule for Soil-Gas Sample Collection for Laboratory Analysis

Shallow Soil-Gas Monitoring Probes	Deep Soil-Gas Monitoring Probes	System Monitoring Soil-Gas Probes	RWQCB-Requested Quarterly Soil-Gas Monitoring Probes
June 11, 2003 July 8, 2003 August 4, 2003 September 9, 2003 October 7, 2003 November 4, 2003	July 8, 2003 September 9, 2003 November 4, 2003	July 8, 2003 September 9, 2003 November 4, 2003	June 11, 2003 September 9, 2003

Table 14. MTBE Concentrations in Performance Goal Monitoring Wells Before and During Biosparging System Operation

Collection Date	MTBE (μg/L)							
	MW-M10	MW-M3	MW-M9	PG-MW1	PG-MW2	PG-MW3	PG-MW4	PG-MW5
6/24/02	11	21,000	500	23,000/22,000	20,000	19,000	14,000/15,000	6,100
10/8/02	3.3	14,000	340	20,000	18,000	10,000	13,000/13,000	4,300
11/11/02	0.83	12,000	470	19,000/20,000	16,000	8,700	13,000	5,100
12/13/02	2.1	12,000	290	22,000	15,000	11,000	12,000	5,500/5,800
1/8/03	<0.5	8,600/8,600	180	18,000	5,400	2,800	8,200	8,300
2/5/03	<0.5	4,100	48	17,000	8,900	2,800/2,900	10,000	8,000
3/5/03	<0.5	4,600	41/43	14,000	6,000	1,300	7,000	5,400
4/2/03	0.31 J	4,200	150	14,000	6,300/5,300	990	6,700	5,600
5/7/03	<0.5	4,400	100	18,000	3,700	1,200	5,000	6,200
6/9/03	0.24 J	5,300	130	14,000	4,900	1,400	5,700/5,400	1,600
7/11/03	0.37 J	7,000	140	12,000	4,000	890/920	3,500	1,700
8/6/03	0.36 J	9,000	140/140	12,000	4,700	1,900	4,700	2,400
9/11/03	0.25 J	8,800	150	13,000	6,500	2,700	3,400	3,300/3,600
10/9/03	0.5	8,100	180	13,000/13,000	8,600	2,300	2,900	2,400
11/5/03	0.58	7,800	210/190	13,000	5,500	5,700	3,100	4,400

Table 15. Summary List of Monitoring Wells Recommended for Sampling Frequency Changes

Well ID	Data Objectives[a]
Quarterly to Semiannually	
MW-6A	▪ Establish concentration trends near former UST 970 to determine if a continuing source to groundwater exists.
IT-1MW-4A	▪ Downgradient transect well to monitor for internal migration of the MTBE plume on former HAAF property. ▪ Compare MTBE concentrations on former HAAF property to established residential risk levels to ensure they are within acceptable levels. ▪ Determine the extent of MTBE impact on Pacheco Creek.
MW-26D	▪ Compare MTBE concentrations on former HAAF property to established residential risk levels to ensure they are within acceptable levels. ▪ Determine whether MTBE is distributed equally between deep and shallow intervals of the aquifer.
Quarterly to Semiannually (After Biosparging Operation Ceases)	
MW-M1 MW-M16	▪ Compare MTBE concentrations on former HAAF property to established residential risk levels to ensure they are within acceptable levels. ▪ Property boundary well to monitor for internal migration of the MTBE plume across State Access Road.
Semiannually to Annually	
IT-EW-91-1	▪ Monitor the outer extent of the MTBE plume boundary on former HAAF property. ▪ Compare MTBE concentrations on former HAAF property to established residential risk levels to ensure they are within acceptable levels.

(a) The data objectives of each well are identified in greater detail in Table 1 of this report. Based on the existing concentration data for each well proposed for less frequent monitoring, all data objectives will continue to be satisfied